Stunning methods and slaughter of rabbits for human consumption

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Stunning methods and slaughter of rabbits for human consumption

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Abstract

This opinion on the killing of rabbits for human consumption ('slaughtering') responds to two mandates: one from the European Parliament (EP) and the other from the European Commission. The opinion describes stunning methods for rabbits known to the experts in the EFSA working group, which can be used in commercial practice, and which are sufficiently described in scientific and technical literature for the development of an opinion. These are electrical stunning, mechanical stunning with a penetrative and non-penetrative captive bolt and gas stunning. The latter method is not allowed in the EU anymore following Council Regulation (EC) No 1099/2009, but may still be practiced elsewhere in the world. Related hazards and welfare consequences are also evaluated. To monitor stunning effectiveness as requested by the EP mandate, the opinion suggests the use of indicators for the state of consciousness, selected on the basis of their sensitivity, specificity and ease of use. Similarly, it suggests indicators to confirm animals are dead before dressing. For the European Commission mandate, slaughter processes were assessed from the arrival of rabbits in containers until their death, and grouped in three main phases: pre-stunning (including arrival, unloading of containers from the truck, lairage, handling/removing of rabbits from containers), stunning (including restraint) and bleeding (including bleeding following stunning and bleeding during slaughter without stunning). Ten welfare consequences resulting from the hazards that rabbits can be exposed to during slaughter are identified: consciousness, animal not dead, thermal stress (heat or cold stress), prolonged thirst, prolonged hunger, restriction of movements, pain, fear, distress and respiratory distress. Welfare consequences and relevant animal-based measures (indicators) are described. Outcome tables linking hazards, welfare consequences, indicators, origins, preventive and corrective measures are developed for each process. Mitigation measures to minimise welfare consequences are also proposed.

Keywords: rabbit, slaughter, hazards, animal welfare consequences, welfare indicators, preventive/corrective measures

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Summary

In 2009, the European Union adopted Council Regulation (EC) No 1099/2009 'on the protection of animals at the time of killing', which was prepared following two scientific opinions adopted by the European Food Safety Authority (EFSA) in 2004 and 2006. Successively (in 2012a, 2013, 2014, 2015 and 2017) EFSA produced other scientific opinions related to this subject.

In parallel, since 2005, the World Organisation for Animal Health (OIE) has developed two chapters in its Terrestrial Animal Health Code: one on the Slaughter of animals (Chapter 7.5), and one on Killing of animals for disease control purposes (Chapter 7.6). OIE has created an ad hoc working group to revise these two chapters.

Against this background, EFSA received two mandates: one from the European Parliament (EP) and the other from the European Commission. The mandate from the EP asks EFSA to indicate the most suitable stunning and killing methods for rabbits and define indicators to assess unconsciousness and death of the animals for the stunning and bleeding phases. The Mandate from the European Commission asks EFSA to provide an independent view on stunning and killing methods for the slaughter of rabbits, covering all parts of the slaughter process. For each of these parts, information on several welfare aspects was requested: welfare hazards, performance indicators and corrective measures.

The mandates from EP and European Commission overlap, in particular on the stunning methods and welfare indicators to be assessed. For this reason, the two mandates were merged into one scientific opinion that includes a description of existing stunning methods for rabbits (relevant for both mandates). It also describes welfare indicators for all phases of the slaughter process (relevant for the European Commission mandate), including indicators for the stunning phase (relevant for both mandates). Emphasis was given to the latter for selecting indicators of the state of consciousness and death based on their sensitivity, specificity and ease of use (relevant for the EP mandate). The opinion also provides welfare hazards for all phases of the slaughter process, and preventive and corrective measures to those hazards (relevant for the European Commission mandate).

In summary, the response to each of the two mandates is as follows.

Summary for the EU Parliament

The opinion describes all stunning methods for rabbits which have been practiced on a commercial scale: electrical stunning, mechanical stunning with a penetrative and non-penetrative captive bolt and gas stunning. The latter method is not allowed in the European Union (EU) anymore following Council Regulation (EC) No 1099/2009, but was included in response to the European Commission mandate. The same applied to the bleeding process which is described for the two scenarios: bleeding following slaughter with stunning and bleeding following slaughter without stunning. Finally, indicators for the state of consciousness and death were selected.

The selection of indicators for the state of consciousness took place on the basis of their sensitivity (Se), specificity (Sp) and ease of use (see methodology in chapter 2.2.3 and results in chapter 3.6.2). The existing scientific literature lacks quantitative information on this, so it was retrieved through an Expert Knowledge Elicitation (EKE) process (see methodology in chapter 2.2.3.2, results in chapter 3.6.2.2 and details in Appendix B). For this, a technical workshop was held to reach consensus among experts on estimates for sensitivity, specificity and ease of use of the various indicators. This was done separately for electrical, mechanical stunning and bleeding. On the basis of this information, so-called 'flow charts' were produced for each stunning method, to support an indicator-based decision process (see methodology in chapter 2.2.3.3 and results in chapter 3.6.3). The flow charts propose toolboxes containing three indicators with high sensitivity (or specificity in case of indicators of death) plus some additional indicators that can also be used, as they are easy to apply. A different toolbox is suggested for each phase of the stunning and bleeding process: immediately following stunning (Key stage 1), just prior to neck cutting (Key stage 2) and during bleeding (Key stage 3). The tool box suggests the next step to be taken: if the animal is still conscious action is required (e.g. re-stunning the animal).

As the Panel could not evaluate the suitability of stunning methods (see Chapter 3.9), the opinion recommends to follow the European Regulation EC 1099/2009 which indicates that the methods to be used for stunning of rabbits are the head-only electrical stunning and the mechanical stunning with a captive bolt. Gas stunning of rabbits has been investigated as a potential alternative method, but is not currently allowed in the European Union.

In Tables 14 and 15, the suggested indicators, and their estimated Se, Sp and ease of use are presented including the degree of uncertainty of these estimates. For electrical and mechanical stunning methods and each of the key stages, it was possible to identify 3–4 indicators that are highly

sensitive in identifying the state of consciousness and that should be used to monitor stunning effectiveness. In addition, a number of indicators, which are not highly sensitive, were selected based on their ease of use and can be used too.

The set of indicators to be used when determining the state of consciousness following head-only electrical stunning in rabbits should consist of (in order of decreasing sensitivity): Key stage 1 (immediately after stunning): corneal or palpebral reflex, tonic/clonic seizures, breathing. In addition, spontaneous blinking and vocalisation can be used but they should not be relied upon solely; Key stage 2 (just prior to neck cutting): corneal or palpebral reflex, tonic/clonic seizures, breathing and righting reflex. In addition, spontaneous blinking and vocalisation can be used; Key stage 3 (during bleeding): corneal or palpebral reflex, breathing, tonic/clonic seizures and righting reflex. In addition, spontaneous blinking and vocalisation can be used.

The set of indicators to be used to determine the state of consciousness following mechanical stunning in rabbits should consist of (in order of decreasing sensitivity): Key stage 1 (immediately after stunning): corneal or palpebral reflex, breathing and tonic/clonic seizures. In addition, spontaneous blinking and vocalisation can be used; Key stage 2 (just prior to neck cutting): corneal or palpebral reflex, breathing and righting reflex. In addition, spontaneous blinking and vocalisation can be used; Key stage 3 (during bleeding): corneal or palpebral reflex, breathing and righting reflex. In addition, spontaneous blinking and vocalisation can be used.

For bleeding, it was possible to identify three indicators that are highly specific to identify that the animals are dead: breathing, cessation of bleeding and muscle tone. In addition, heart beat and dilated pupils can be used but they should not be relied upon solely. The estimates for specificity, ease of use and associated uncertainties can be found in Table 16.

Summary for the European Commission

The European Commission mandate asked EFSA to identify the animal welfare hazards and their possible origins in terms of facilities/equipment and staff (Term of Reference (ToR)-1); define indicators of animal welfare, including animal-based measures to assess the state of consciousness (ToR-2); provide preventive and corrective measures (structural or managerial) to address the hazards identified (ToR-3); point out specific hazards related to species or type of animal (e.g. young ones, etc.) (ToR-4), and to identify suitable and unacceptable methods for stunning and killing rabbits, based on welfare grounds.

The above ToRs refer to all phases of the slaughter process: arrival of the animals, unloading, lairage, restraint, stunning, bleeding and emergency killing.

Council Regulation (EC) No 1099/2009 defines slaughtering as 'the killing of animals intended for human consumption' and the related operations are 'operations that take place in the context and at the location where the animals are slaughtered.' In the context of this opinion, the operations are grouped in phases. They are: Phase 1 – pre-stunning, Phase 2 – stunning and Phase 3 – bleeding. Phase 1 includes the following processes (in chronological order): a) transportation (excluded from this scientific opinion), b) arrival, c) unloading of containers from the truck, d) lairage and e) handling and removing of animals from containers. Considering that the restraint of rabbits prior to stunning varies depending on the stunning method, restraint has been assessed as a part of the relevant stunning method (Phase 2). The bleeding phase (Phase 3) includes: a) the bleeding of rabbits following stunning and b) the bleeding during slaughter without stunning, including the restraint.

To address the mandate, two main approaches were used in developing this opinion: i) literature search and ii) expert opinion through working group (WG) discussion. The literature search was carried out to identify peer-reviewed scientific evidence providing information on the elements requested by the ToRs (i.e. description of the processes, identification of welfare hazards and their origin, preventive and corrective measures, welfare consequences and related indicators) on the topic of slaughter of rabbits (killing for human consumption).

From the available literature and their own knowledge, the WG experts identified the processes that should be included in the assessment and produced a list containing the possible welfare hazards of each process. To address the ToRs, experts identified the origin of each hazard (ToR-1) and related preventive and corrective measures (ToR-3), along with the possible welfare consequences of the hazards and relevant indicators (ToR-2). Measures to mitigate the welfare consequences were also considered. Specific hazards were identified in the case of certain categories of rabbits, such as long haired animals. In addition, uncertainty analysis on the hazard identification process was carried out, but limited to the quantification of the probability of the occurrence of false-positive or false-negative hazards.

As this opinion will be used by the European Commission to address the OIE standards, more methods for slaughter were considered than those that are compliant with Council Regulation (EC) No 1099/2009. To decide on what to include, three criteria were applied in the selection process. Firstly, all methods with described technical specifications known to the experts were considered, not only those described in Council Regulation (EC) No 1099/2009. Secondly, only methods currently used for slaughter of rabbits as well as those still in development (but likely to become commercially applicable) were included. Finally, only those methods for which the welfare aspects (in terms of welfare hazards, welfare consequences, indicators, preventive and corrective measures) are described sufficiently in the scientific literature were included. As a result, there may be methods that are applied worldwide but that are not included in the current assessment.

The stunning methods that have been identified as relevant for rabbits can be grouped in three categories: 1) electrical, 2) controlled atmospheres and 3) mechanical. Electrical methods include head-only stunning. Controlled atmosphere stunning methods (CAS) include gas stunning. Low Atmosphere Pressure Stunning (LAPS) was not considered. The mechanical methods that have been described in this report are penetrative and non-penetrative captive bolt and percussive blow to the head.

In this opinion, for each process related to slaughter, a description on how it is technically and practically carried out and how the animals are restrained (e.g. in containers, manually or in a restraint device) is provided. In addition, a list of the main identified hazards that could occur during the process as well as their welfare consequences was included. Finally, a third section with a brief description of the key points for the assessment of rabbit welfare was also included.

In answering ToR-1, 28 welfare-related hazards were identified, from arrival of the animals at the slaughter plant until they were dead. Some of these hazards were common to different phases. All the processes described in this opinion have hazards.

Some hazards are inherent to the stunning method and cannot be avoided (e.g. exposure to too high CO_2 concentration), and other hazards originate from suboptimal application of the method, mainly due to unskilled staff (e.g. rough handling, use of wrong parameters e.g. for electrical methods). In fact, most of the hazards (25) had staff as origin, and most were attributed to lack of appropriate skill sets needed to perform tasks or to fatigue.

The uncertainty analysis on the set of hazards provided in this opinion for each process revealed that the experts were 90–95% certain they identified all welfare hazards according to the three criteria described in the Interpretation of ToRs. However, when considering a global perspective, the experts were 95–99% certain that at least one welfare hazard is missing (owing to the lack of documented evidence on all possible variations in the processes and methods being practiced on a worldwide scale). Regarding the possible inclusion of false-positive hazards, the experts were 95–99% certain that all listed hazards exist during the slaughter of rabbits.

The mandate also asked for definitions of qualitative or measurable (quantitative) criteria to assess performance (i.e. consequences) on animal welfare (indicators; ToR-2). This was addressed by identifying the negative consequences on the welfare (so-called 'welfare consequences') and the relevant indicators that can be used to assess qualitatively or quantitatively these welfare consequences. Ten welfare consequences were identified: consciousness, animal not dead, thermal stress (heat or cold stress), prolonged thirst, prolonged hunger, restriction of movements, pain, fear, distress and respiratory distress. Rabbits experience these welfare consequences only when they are conscious; all animals will therefore experience the welfare consequences of the hazards occurring in the pre-stunning phase, in restraint (when applied to conscious animals) and in slaughter without stunning. Only a proportion of animals will be subjected to the welfare consequences of hazards they are exposed to after stunning: these are the animals for which stunning was ineffective or which recovered consciousness before death.

A list including definitions of indicators to be used for assessing the welfare consequences has been provided in this Opinion. However, under certain circumstances, not all the indicators can be used because of low feasibility (e.g. at arrival/during lairage due to the lack of accessibility to the animals in containers). Even if welfare consequences cannot be assessed during the slaughter of rabbits, it does not imply they do not exist; in fact, if the hazard is present, it should be assumed that the related welfare consequences are also experienced by the rabbits.

In response to ToR-3, preventive and corrective measures for the identified hazards have been identified and described. Some are specific for a hazard; others can apply to multiple hazards (e.g. staff training and rotation). For most of the hazards (25), preventive measures can be put in place with management having a crucial role in prevention. Corrective measures were identified for nine hazards; when they are not available or their implementation is not feasible, actions to mitigate the welfare consequences caused by the identified hazards should be put in place.

Finally, outcome tables that concisely link all the elements requested by the ToRs (identification of welfare hazards, origin, preventive and corrective measures, welfare consequences and related indicators) for each process in the slaughter of rabbits were produced. The conclusions and recommendations of this scientific opinion are mainly based on these outcome tables. Specific recommendations are provided for specific processes of slaughter. To spare rabbits from severe welfare consequences such as pain and fear: a) animals should not be shackled whilst conscious, b) animals should not be bled whilst conscious and c) death must be monitored and confirmed in rabbits before the dressing starts.

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1. Introduction

Background and Terms of Reference as provided by the requestor

This scientific opinion (EFSA-Q-2018-00909) covers welfare aspects of rabbits slaughtered for human consumption, as a result of two requests received by the European Parliament (M-2018-0124) and the European Commission (M-2018-0182).

Background and Terms of Reference from the European Commission

The Union adopted in 2009 Council Regulation (EC) No 1099/2009[1] on the protection of animals at the time of killing. This piece of legislation was prepared based on two EFSA opinions adopted in 2004 and 2006 (EFSA, 2004, 2006). The EFSA AHAW Panel provided additional opinions related to this subject (EFSA AHAW Panel, 2012a,b, 2013a–f, 2014a,b, 2015, 2017a,b). In parallel, since 2005, the World Organisation for Animal Health (OIE) has developed in its Terrestrial Animal Health Code two chapters covering a similar scope:

- Slaughter of animals (Chapter 7.5);
- Killing of animals for disease control purposes (Chapter 7.6)

The OIE has decided to revise these two chapters. The chapter on the slaughter of animals covers the following species: cattle, buffalo, bison, sheep, goats, camelids, deer, horses, pigs, ratites, rabbits and poultry (domestic birds as defined by the OIE).

The Commission requested EFSA to review the scientific publications provided and possibly other sources to provide a sound scientific basis for the future discussions at international level on the welfare of animals in the context of:

- slaughter i.e. killing animals for human consumption
- other types of killing i.e. killing for purposes other than slaughter

Two categories of animals must be addressed: i) free-moving animals (cattle, buffalo, bison, sheep, goats, camelids, deer, horses, pigs, ratites) and ii) animals in crates or containers (i.e. rabbits and domestic birds).

The opinion should cover the following slaughter processes and issues: arrival of the animals at the abattoir, unloading, lairage, handling and moving of the animals (free-moving animals only), restraint, stunning, bleeding, slaughter of pregnant animals (free-moving animals only), emergency killing (reasons and conditions under which animals must be killed outside the normal slaughter line), unacceptable methods, and any particular procedures or practices on welfare grounds.

For every process or issue in each category, EFSA will:

- Identify the animal welfare hazards and their possible origins (either facilities/equipment or staff);
- Define qualitative or measurable criteria to assess performance on animal welfare (animal-based measures (ABM));
- Provide preventive and corrective measures to address the hazards identified (through structural or managerial measures);
- Point out specific hazards related to species or types of animals (young, with horns, etc.).

Background and Terms of Reference from the European Parliament

Rabbit farming for meat production is of importance worldwide, including in the EU where rabbits are the second most farmed species in terms of numbers. Welfare of farmed rabbits was raised and discussed in an European Parliament (EP) meeting and a "Motion for a European Parliament resolution on minimum standards for the protection of farm rabbits" was developed by the Committee on Agriculture and Rural Development in January 2017. The Committee proposed that the setting of minimum standards for the protection of farm rabbits could be assisted by an independent scientific opinion from EFSA. In 2005 and 2006, EFSA has published scientific opinions on i) the impact of housing and husbandry systems on the health and welfare of farmed domestic rabbits and ii) welfare aspects of the main systems of stunning and killing of farmed deer, goats, rabbits, ostriches, ducks and geese, respectively.

[1] Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. OJ L 303, 18.11.2009, p. 1–30.

The EU Parliament therefore considers it opportune to request EFSA to update its scientific opinions on different aspects of health and welfare of rabbits kept for meat production in Europe, including rabbit slaughter.

The opinion should include the indication of the most suitable method for stunning and killing of rabbits, including indicators to assess unconsciousness and death of the animals.

Merging of Terms of Reference from the European Commission and the European Parliament

The mandates from EP and EC overlap on the request for indicators to assess the welfare performance of the methods and procedures. The mandate from EP requests indicators of unconsciousness and death for the stunning phase. In addition, the mandate from EC request indicators for all phases of the process. To structure EFSA's response to the two mandates, a set of 5 Terms of Reference (TORs) were identified that cover them both. They are presented below, with reference to the original requests in the EP and EC mandates. From here onwards, this opinion will refer and respond to these TORs.

Table 1: Merging of Terms of Reference

TORs	Origin	Description
ToR1	EC	To identify the animal welfare hazards and their possible origins (facilities/equipment, staff)
ToR2	EP & EC	To define indicators of animal welfare, including animal-based measures to assess the state of consciousness This TOR is based on both mandates: i) EC: define qualitative or measurable criteria to assess performance on animal welfare (animal-based measures) for all phases of the process ii) EP: Indicators to assess unconsciousness and death of the animals - for slaughter with or without stunning
ToR3	EC	To provide preventive and corrective measures to address the hazards identified (through structural or managerial measures)
ToR4	EC	To point out specific hazards related to species or types of animals (young, with horns, etc.)
ToR5	EP & EC	To identify suitable and unacceptable methods for stunning and killing rabbits, based on welfare grounds This TOR is based on both mandates: EP: Include the indication of the most suitable method for stunning and killing of rabbits EC: the opinion should include unacceptable methods, procedures or practices on welfare grounds

Interpretation of the Terms of Reference

As explained above, this scientific opinion will respond to the ToRs from both the mandate from the EP and that of the EC. The Mandate from the EC asks EFSA to provide an independent view on the slaughter of rabbits (killing for human consumption), covering all parts of the slaughter process. For each of these, several welfare aspects need to be analysed (including, e.g., welfare hazards, performance criteria and corrective measures). The mandate from the EP asks EFSA to indicate the most suitable stunning and killing methods for rabbits and define indicators to assess unconsciousness and death of the animals for the stunning and bleeding phases. This opinion will be dedicated to animals in crates and containers and specifically to rabbits kept for meat production.

This opinion will use definitions related to the killing of rabbits, including the related operations, provided by the Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing, which entered into force in January 2013. The Regulation defines 'slaughtering' as the killing of animals intended for human consumption; the 'related operations' are operations such as handling, lairaging, restraining, stunning and bleeding of animals that take place in the context and at the location where the animals are slaughtered.

Therefore, this opinion will focus on the killing of rabbits for human consumption which could take place in a slaughter plant or during on-farm slaughter, from the arrival until the animal is dead (including slaughter without stunning). In the context of this opinion, each related operation is a 'process' and several related operations (processes) are grouped into 'phases'. The phases that will be assessed in this opinion, from arrival until the animal is dead (including slaughtering without stunning), are:

Phase 1 - pre-stunning, Phase 2 - stunning, and Phase 3 - bleeding. Phase 1 includes in chronological order: (a) transportation (excluded from this scientific opinion), (b) arrival, (c) unloading of containers from the truck, (d) lairage, and (e) handling and removing of rabbits from containers. Considering that the restraint of rabbits prior to stunning varies depending on the stunning method, restraint will be assessed as a part of the relevant stunning method (Phase 2). The bleeding phase (Phase 3) includes: (a) the bleeding of rabbits following stunning and (b) the bleeding during slaughter without stunning including the restraint.

The mandate requests EFSA to identify hazards at different stages (processes) of slaughtering and their relevant origins in terms of equipment/facilities or staff (ToR-1). Some hazards may originate from the farm or during transport; however, on-farm animal rearing, catching and transport are excluded from this assessment.

This opinion will report the hazards that can occur during slaughtering of rabbits in all slaughterhouses (from industrial plants with automated processes to on-farm manual slaughter), but not all of them apply to all slaughter situations, i.e. in small abattoirs or during on-farm slaughter. Indeed, hazards applicable to a specific stunning method may occur to all situations where this method is applied, whereas some other hazards may not apply in certain circumstances like slaughter on-farm (e.g. the ones specific of the arrival or unloading of containers).

It is to be noted that the mandate does not specify the level of detail to be considered for the definition of 'hazard'. One hazard could be subdivided into multiple smaller ones depending on the chosen level of detail. For example the hazard "inappropriate electrical parameters" could be further subdivided into "wrong choice of electrical parameters or equipment", "poor or lack of calibration", "application of voltage/current at too low a level", "frequency of current applied is too high for the amount of current delivered". For this opinion it was agreed to define hazards by a broad level of detail ('inappropriate electrical parameters' in the above example).

The mandate also requires indicators of animal welfare to be defined (ToR2), namely qualitative or measurable (quantitative) criteria to assess performance on animal welfare. This ToR has been addressed firstly for the EC mandate by identifying the negative consequences on the welfare (so called 'welfare consequences') occurring to the rabbits due to the identified hazards and the relevant indicators that can be used to assess qualitatively and/or quantitatively the welfare consequences for all phases of the slaughter process. In some circumstances it might be that no indicators exist or are not feasible to use in the context of slaughtering of rabbits; in these cases, emphasis to the relevant measures to prevent the hazards or to mitigate the welfare consequences will be given. In this opinion, in the description of the processes of each phase, the relevant negative welfare consequences that the rabbits can experience when exposed to hazards will be also reported.

This ToR also addresses the selection of indicators for unconsciousness and death for the EP mandate. However, when monitoring the effectiveness of stunning, it is common to look for indicators of 'consciousness', instead of 'unconsciousness'. This is because in the slaughterhouse process corrective action is required when 'consciousness' is detected (e.g. animals will have to be re-stunned and or the stunning process adjusted). Therefore, ToR2 refers to 'the state of consciousness', and when indicators are referred to they will be called 'indicators of consciousness'.

Overall for this ToR, the circumstances when factors may become hazards in practice are described in the description of the hazards. Additionally, in the description of the welfare consequences, the biological effects on the animals are reported. Furthermore, the description of the indicators includes mention of how the welfare consequences on the animals can be measured. This opinion will also propose preventive and corrective measures that can be put in place by the food business operator in order to prevent or correct for the identified hazards. These measures will involve two main categories: 1) structural and 2) managerial (ToR3). When corrective measures for the hazards are not available or feasible to put in place, actions to mitigate the welfare consequences will be discussed. In addition, it will be assessed whether specific categories or species of domestic rabbits might be subjected to specific hazards (ToR-4). As an additional request from the EC, measures to mitigate the welfare consequences will also be described under ToR-2.

Rabbits experience negative welfare consequences only when they are conscious. In practice, this may apply to all rabbits during the pre-stunning phase. In the stunning phase rabbits may experience negative welfare consequences if hazards occur during restraint (when restrained before stunning), if induction of unconsciousness is not immediate or in the case of ineffective stunning. During bleeding – following stunning – rabbits will experience welfare consequences in case of persistence of consciousness or if they recover consciousness after stunning and before death. When rabbits are slaughtered without stunning all the rabbits will experience the welfare consequences related to the hazards they are subjected to. Therefore, consciousness is an important prerequisite to experience welfare consequences.

The EC mandate does not specify which specific stunning and killing systems need to be included in this analysis, and the EC wants to use this opinion to address the OIE standards. Therefore, this opinion will consider more methods than those reported in Council Regulation (EC) No 1099/2009, potentially even those which are not allowed by the Regulation. However, there are many methods worldwide for slaughtering of rabbits, and they cannot all be included in this opinion. EFSA has applied the following criteria for the selection of stunning and killing methods to include:

a) all methods with described technical specifications known by the experts will be considered and not only the method described in Council Regulation (EC) No 1099/2009, and
b) only methods that were or are currently used for slaughter, and those which are still under development but are likely to become commercially applicable, and
c) only methods for which the welfare aspects (in terms of welfare hazards, welfare consequences, animal-based measures, preventive and corrective measures) are described sufficiently in the scientific literature.

2. Data and methodologies

2.1. Data

2.1.1. Data from literature

Information from the papers selected as relevant from the literature search described in Section 2.2.1 and from additional literature identified by the working group (WG) experts was used for a narrative description and assessment to address ToRs 1, 2, 3 and 4 (see relevant sections in the Assessment chapter).

2.1.2. Data from expert opinion

The data obtained from the literature were complemented by the WG experts' opinion in order to identify the origins of hazards, welfare consequences, indicators and hazard preventive and corrective measures relevant for the current assessment. The resulting elements were used to address the mandate extensively (see relevant sections in the Assessment chapter) as well as in a more concise way with the development of outcome tables (see Section 2.2.3).

2.2. Methodologies

Three main approaches were used to develop this opinion: i) literature search, ii) expert knowledge elicitation (EKE) for the selection of indicators for phase 2 and 3 (stunning and bleeding) and iii) expert opinion through working group discussion.

The general principle was adopted that, when scientific literature supporting the text was available, the relevant reference/s would be cited in the body of the document and when no references were available, expert opinion would be used. If no references are reported in the text, the statement will be supported by expert opinion.

2.2.1. Literature search

A literature search was carried out to identify hazards related to animal welfare during slaughter of rabbits in peer-reviewed and grey literature.

The search was carried out in the information resources listed in Appendix A. The restrictions that were applied in the search strings were related to the date of publication: only those published after the EFSA's opinion 'The welfare aspects of the main systems of stunning and killing the main commercial species of Animals, 2004' (EFSA, 2004) were considered. No language or document type restrictions were applied in the search strings. Full details of the search protocol and strategies are provided in Appendix A.

The search yielded a total of 53 records which were exported to EndNote x7 together with the relevant metadata (e.g. title, authors, abstract). A first screening of all titles and abstracts was performed to remove articles related to species, productive systems, phases and research purposes that were out of the scope of this opinion, leading to 20 records. The identified papers were used to underpin the indicators during different phases of the slaughter process.

The reference lists of relevant review articles and key reports were checked for further relevant articles. Experts were invited to propose any additional relevant publications they considered very important, including the ones published before 2004.

2.2.2. Expert opinion through working group discussion

The WG experts firstly described the phases and the related processes of slaughter and specifically which stunning/killing methods should be considered for the current assessment.

The experts then produced from the available literature and their own knowledge a list containing the possible welfare hazards characterising each process related to slaughter of rabbits. To address the ToRs, experts identified hazards' origins and related preventive and corrective measures, the possible welfare consequences of the hazards and relevant indicators. These were then reported in so-called 'Outcome Tables' (see Section 2.2.3).

To support the interpretation of the outcomes, the experts also considered the uncertainty related to their assessment (see Section 2.2.5).

2.2.3. Development of outcome tables linking the elements of the ToRs

The results of the current assessment related to ToR-1, 2 and 3 were summarised in 'Outcome Tables' (see Section 3.10) following the conceptual model shown in Figure 1.

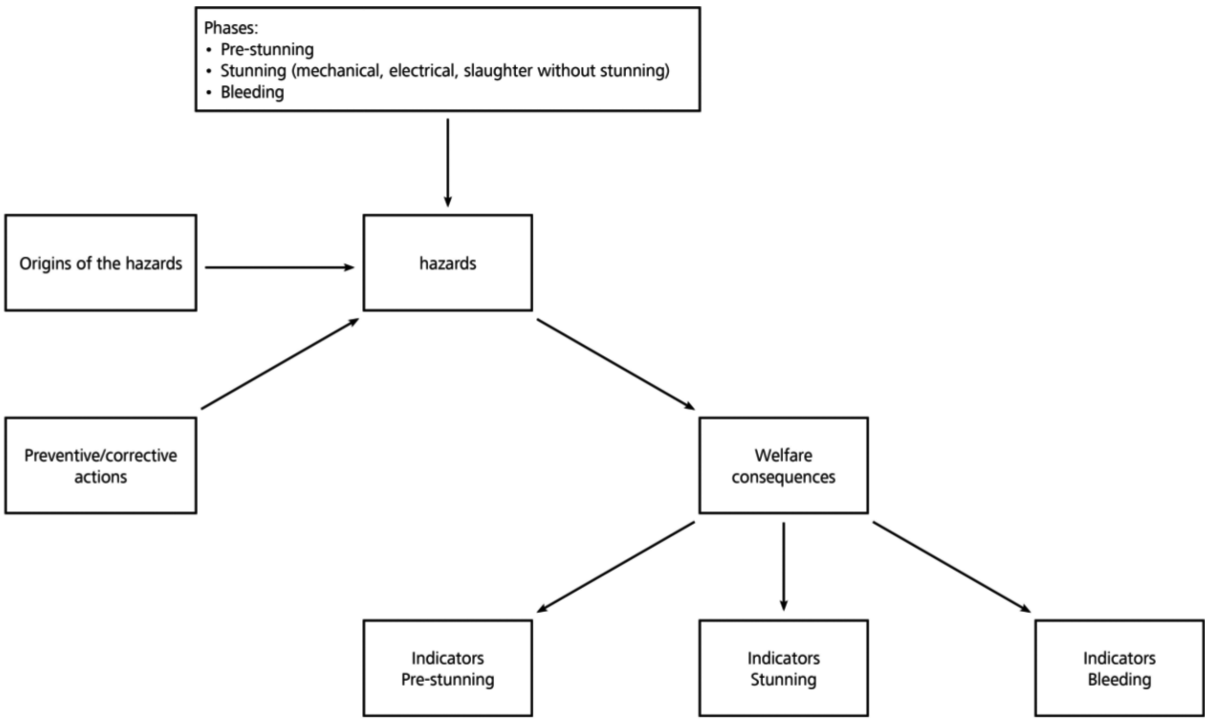


Figure 1: Conceptual model showing the interrelationships among elements corresponding to the different ToRs

The outcome tables have the following structure and the following terminology should be referred to:

'OUTCOME TABLE': Each table represents the summarised information for each process of slaughter of rabbit described in Sections 3.1–3.3. Therefore, in total there are 10 tables corresponding to the total number of processes pertaining to the slaughter of rabbits that were analysed.

COLUMN 'HAZARD': in each table, the first column reports all hazards pertaining to the specific process related to slaughter; in bracket, the number of the section where each hazard is described in detail is reported.

'ROW': For each hazard, the individual row represents the summarised information relevant to the elements analysed for that hazard.

COLUMN 'WELFARE CONSEQUENCES OCCURRING TO THE RABBITS DUE TO THE HAZARD': this lists the welfare consequences to the rabbits due to the hazards mentioned.

COLUMN 'HAZARD ORIGIN': this identifies the category of the hazard origin, which can be staff-, equipment- or facility-related. Most hazards can have more than one origin.

COLUMN 'HAZARD ORIGIN SPECIFICATION': this provides details of the origin(s) of the hazard. This information is needed to understand and choose among the available preventive and corrective measures.

COLUMN 'PREVENTIVE MEASURE/S OF THE HAZARD': depending on the origin/s of the hazard, several measures are proposed to prevent the hazard. They are also elements for implementing standard operating procedures (SOP).

COLUMN 'CORRECTIVE MEASURE/S OF THE HAZARD': practical actions/measures for correcting the identified hazards are proposed. These actions may relate to the identified hazard's origins.

ROW 'WELFARE INDICATORS': list of feasible measures to be performed on the rabbits in order to assess the welfare consequences of a hazard.

Each outcome table represents a process of slaughtering of rabbits. Each row of the table reports the link between a hazard, the relevant welfare consequences and related indicators, the hazard's origins and the preventive and corrective measures. An example is reported in Table 2, concerning the hazard 'too high effective temperature' during the phase 'arrival'.

Table 2: Example of a row of an outcome table

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Too high effective temperature	Heat stress	Equipment, facilities, staff	Environment, not enough ventilation in the truck, prolonged waiting time	– Increase space allowance – avoid hottest hours of the day for transport – unload immediately following the arrival – provide adequate ventilation to the truck at arrival place – misting or nebulisation assuring appropriate ventilation – protect from adverse weather conditions	– Provide adequate ventilation, – unload the truck immediately and bring the rabbits to a thermal neutral zone

The outcome tables are considered the main result of this scientific opinion, since all the collected information is presented there concisely. The Conclusions and Recommendations of this scientific opinion are mainly based on the outcome tables.

2.2.4. Methodology for selection of indicators for phase 2 and 3 (stunning and bleeding)

To facilitate the selection of the most appropriate indicators for monitoring the efficacy of stunning, EFSA developed a methodology in a series of opinions on monitoring procedures at slaughter (EFSA AHAW Panel, 2013c–f). This approach was adopted in the current opinion to select the indicators for monitoring the state of consciousness and death after stunning and during bleeding. The methodology involves indicator selection based on their ease of use, their specificity and their sensitivity. Their reliability is critical to ensure that progress to a subsequent step in the process is required.

2.2.4.1. Considerations on sensitivity, specificity and ease of use of the indicators

Regarding sensitivity and specificity, the use of indicators of consciousness can be regarded in the same way as the use of a diagnostic test with either a positive or negative outcome.

Appendix B of this opinion explains how this is applied to indicators of consciousness and death. It results in the following definitions:

During slaughter *with prior stunning*, an indicator for consciousness is considered to be 100% sensitive if it identifies all the conscious animals as conscious; an indicator is considered to be 100% specific if it identifies all the unconscious animals as unconscious.

During slaughter with stunning or without prior stunning, indicators of death should be used to confirm the animal is dead before dressing. An indicator for death is considered to be 100% sensitive if it identifies all dead animals as dead. An indicator is considered to be 100% specific if it identifies all live animals as alive. In this case, the aim of the indicator assessment is to identify the welfare problem, and therefore, indicators with a high specificity is preferred (more detail Appendix B).

The ease of use of an indicator is considered in relation to physical aspects of its assessment. These include, for example, the position of the animal relative to the assessor, the assessor's access to the animal and the line speed. Ease of use for the purpose of this opinion does not include economic aspects. It is very likely that the ease of use of assessing an indicator is closely linked to the stage of the slaughter process: animals can be in different positions and proximity relative to the assessor during or after stunning, at sticking/neck cutting or during bleeding.

The estimates for ease of use, specificity and sensitivity of possible indicators were obtained through a formal EKE.

2.2.4.2. EKE methodology to estimate sensitivity, specificity and ease of use of the indicators of unconsciousness and death

EKE is a systematic, documented and reviewable process to retrieve expert judgements from a group of experts. The EFSA Guidance on EKE (EFSA, 2014) provides detailed protocols for obtaining expert judgement in the areas covered by EFSA's food safety remit.

In this opinion, a Delphi approach was used. A small group of experts was invited to an EKE workshop where the information about sensitivity and specificity of the indicators was elicited by asking respondents to estimate, for each indicator, the proportion of truly conscious and the proportion of truly unconscious animals that would be considered conscious, based on the outcome of the indicator.

Regarding ease of use, questions were asked on how easily the indicators are applied and checked during the stunning and slaughter process using three categories: easy, moderate and difficult (to apply).

For all parameters, a group discussion was performed after which individual judgements were given by the experts. For the final outcome, the individual judgements were aggregated using equal weights.

The outcome of this elicitation was graphs in which the sensitivity, specificity and ease of use of the selected indicators were shown. They were done for each of three phases in the process: immediately following stunning, at the time of neck cutting and during bleeding. Before bleeding or in case of slaughter without stunning, one graph was produced to reflect the bleeding phase. More information about the EKE workshop is given in Appendix B, while the graphs are reported in Appendix C.

Development of flow charts of indicators for monitoring rabbit slaughter

To support the decisions regarding the slaughter process (stunning, sticking and dressing), three flow charts were prepared following the approach of EFSA (EFSA AHAW Panel, 2013c–f): two for monitoring of the state of consciousness after stunning (electrical and mechanical stunning) and one to confirm death prior to dressing (in case of slaughter with stunning) or during bleeding (in case of slaughter without stunning).

The flow charts contain indicators to assess the state of consciousness and death, according to one of three categories:

1) Indicators that are recommended to be used when assessing the state of consciousness
2) Additional indicators that could be used, but which are less reliable (for whatever reason)
3) Indicators which are not recommended to be used.

The categorisation of indicators took place on the basis of their sensitivity, specificity and ease of use. For the indicators included in the first category, the criterion for selection was the highest estimate for sensitivity (Se) for indicators of consciousness and specificity (Sp) for indicators of death in order of decreasing uncertainty interval. Following selection of maximum four indicators, two additional indicators were selected based on their ease of use (easy, moderate or difficult to use) combined with related uncertainty.

2.2.5. Uncertainty analysis

The uncertainty of this opinion was addressed differently for the two sets of ToRs: 1) for the ToRs from the European Commission mandate, the uncertainty assessment was performed on the information presented in the Outcome Tables for all stages of the slaughter process; 2) for the ToRs from the EP mandate, the uncertainty about the sensitivity and specificity was assessed through an EKE process and is therefore represented by a probability distribution.

Uncertainty analysis about the outcome tables

The outcome tables include qualitative information on the hazards and related elements identified through the methodologies explained in Section 2.2.

When considering the outcome tables, uncertainty exists at two levels: i) related to the completeness of the information presented in the table, namely to the number of rows within a table (i.e. hazard identification) and ii) related to the information presented within a row of the table (i.e. completeness of hazard origins, preventive and corrective measures on the one side and welfare consequences and indicators on the other side).

However, owing to the limited time available to develop this scientific opinion, there will not be an uncertainty analysis for the latter level, but only for the first level, i.e. for the hazard identification.

In such a process of hazard identification, uncertainties may result in false-negative or false-positive hazard identifications:

- Incompleteness (false negative): Some welfare-related hazards may be missed in the identification process and so would be considered non-existent or not relevant.
- Misclassified (false positive): Some welfare-related hazards may be wrongly included in the list of hazards of an outcome table without being a relevant hazard.

Incompleteness (false negatives) can lead to underestimation of the hazards with a potential to cause (negative) welfare consequences.

The uncertainty analysis was limited to the quantification of the probability of false-negative or false-positive hazards. False-negative hazards can relate to i) the situation under assessment i.e. limited to the slaughter practices considered in this assessment according to the three criteria described in the Interpretation of ToRs (see Section 1) or ii) the global situation i.e. including all possible variations to the slaughter practices that are employed in the world, and that might be unknown to the experts of the WG. The Panel agreed it was relevant to distinguish the false-negative hazard identification analysis for these two cases.

For false-negative hazard identification, the experts elicited the probability that at least one hazard was missed in the outcome table. For false-positive hazard identification, the experts elicited the probability that each hazard included in the outcome table was correctly included.

For the elicitation, the experts used the approximate probability scale (see Table 3) proposed in the EFSA uncertainty guidance (EFSA Scientific Committee, 2018). Individual answers were first elicited and discussed, and a consensus judgement was elicited.

A qualitative translation of the outcome of the uncertainty assessment was also derived (e.g. 'extremely unlikely' for an uncertainty of 1–5%: see Table 3).

Table 3: Approximate probability scale (see EFSA Scientific Committee, 2018, Table 4)

Probability term	Subjective probability range	Additional options	
Almost certain	99–100%	More likely than not: > 50%	Unable to give any probability: range is 0–100% Report as 'inconclusive', 'cannot conclude' or 'unknown'
Extremely likely	95–99%		
Very likely	90–95%		
Likely	66–90%		
About as likely as not	33–66%		
Unlikely	10–33%		
Very unlikely	5–10%		
Extremely unlikely	1–5%		
Almost impossible	0–1%		

Uncertainty analysis about indicator sensitivity and specificity

During the EKE workshop, the discussion focussed on reasons for possible low or high sensitivity, and low or high specificity of the indicators. The discussions addressed variations between slaughterhouses and slaughterhouse practices, and differences of circumstances within Europe. An approach was agreed for discussion and explanation of the values for sensitivity and specificity.

For each question, the experts were asked to give a reasonable range (minimal and maximal values) of the average sensitivity. They were also asked to judge the probability that this range includes the (unknown) true value. Finally, the experts were asked to state a median value, that neither over- nor underestimated the unknown true value.

To construct the distribution of an individual answer, uniform distributions were assumed below and above the median with equal probability each. The range was extended to comprise the full distribution (100% probability to cover the true value).

The answers of the experts were aggregated afterwards to construct the common uncertainty distribution. According to the EKE guidance, this was done using an equal weighted superimposition of the individual answers (range, coverage and median), followed by a fitting of a Beta-distribution to smooth the outcome. See Figure 2.

Figure 2: Process of fitting of a Beta-distribution to smooth the outcome

The Beta distribution was used to calculate the median and 90% uncertainty range of the common judgement.

Uncertainty analysis about the easiness to apply an indicator

For the ease of application, the categories were scored with 1, 2 and 3 as follows:

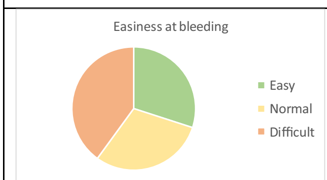
Table 4: Category codes for ease of application

Category	Score
Easy	1
Moderate (Normal)	2
Difficult	3

The uncertainty of the judgement is expressed as the distribution of individual answers within the expert group from which a single measure of certainty (based on the standard deviation) was derived.

An example is presented below in Table 5 for the indicator 'easiness during bleeding'. In this example, three experts judged it as easy, three experts judged it to be moderate and four as difficult to assess.

Table 5: Example of distribution of judgments for ease of application of an indicator

Distribution of judgements	
	3 experts: Easy (score of 1) 3 experts: Moderate (score of 2) 4 experts: Difficult (score of 3)
	Average: ((3*1)+(3*2)+(4*3)) / 10 = 2.1

The average value was then used for the final judgement, as follows

Table 6: Translation of the average answer into a category for ease of application

Average	Easiness
$1 \leq \times \leq 1.67$	Easy
$1.67 < \times \leq 2.33$	Moderate
$2.33 < \times \leq 3$	Difficult

In this example, the final judgement about easiness of this indicator would be 'Moderate'.

The uncertainty within the judgements of 'Easiness of application' was assessed by comparing the observed distributions of the responses of the experts with a uniform distribution among the three categories (easy, moderate, difficult in a scale 1–100%). More detail is provided in Appendix C.

To support the interpretation, following classes are used:

80% ≤ uncertainty ≤ 100% is regarded as high uncertainty;
50% < uncertainty < 80% is regarded as medium uncertainty;
0% ≤ uncertainty ≤ 50% is regarded as low certainty.

In the example, the uncertainty would be 'High' (83%).

3. Assessment

In Sections 3.1–3.3, the relevant slaughter processes are described in three parts. Each section starts with a description of the method used, it then adds an overview of the hazards and the welfare consequences that rabbits can experience, and it ends with the key points for assessing animal welfare (see Figure 3 here below).

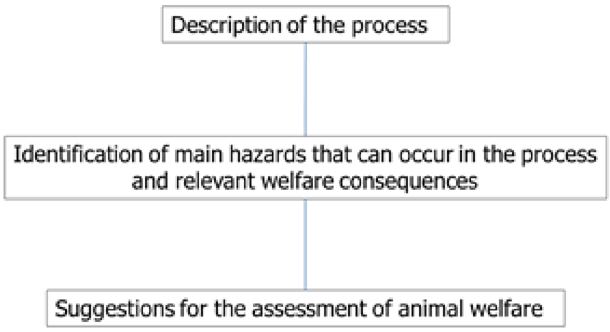


Figure 3: Structure of the sections on the processes assessed in this scientific opinion (Sections 3.1.1–3.3.2)

The details of the hazards' characterisation and origins (ToR-1) and the full description of hazards' preventive and corrective measures (ToR-3) are discussed in Section 3.6.

The description of the welfare consequences, of the related indicators (ToR-2) and of the measures to mitigate the welfare consequences is provided in Section 3.7.

Section 3.4 deals with the 'emergency killing', respectively.

The preventive measures (ToR-3) that are considered general and applicable to several hazards and processes are presented in Section 3.7.

Specific hazards for animal categories (ToR-4) are reported in Section 3.8.

Considerations about 'unacceptable methods, procedures or practices on welfare grounds' and 'suitable stunning methods' are given in Section 3.9 (ToR-5).

Finally, outcome tables (see Section 3.10) link each hazard to the relevant welfare consequences (and related indicators and mitigation measures), hazard's origins and hazard's preventive and corrective measures.

3.1. Description of pre-stunning (phase 1) and relevant welfare consequences

The pre-stunning phase includes four processes: arrival, unloading of containers from the truck, lairage, handling and removing of rabbits from the containers. These processes are described in the following Sections 3.1.1–3.1.4.

The transport period is outside of this scope but as the conditions and the time of transportation will influence the state of welfare of the animals at the arrival stage (EFSA AHAW Panel, 2011), some keys elements are given in the preamble below.

Regarding the time of transport, some authors showed that in Spain, on a sample of 21 hauliers, the mean time was 154 min (Range: 20–600 mins), 14% of them lasted less than 30 min and 19% lasted more than 180 min. Most journeys (67%) were in the morning. At the abattoir, animals were unloaded almost immediately (the average waiting time before unloading was 4.5 min) (Buil et al., 2004).

Animals transported for a long time without water and food will have to be slaughtered faster than those with shorter transport times to avoid a too long time fasting. Caucci et al. (2018) retrospectively analysed 6,411 fattening rabbit and 450 breeding rabbit batches transported in a 3-year period to a major abattoir of Northeast Italy. Both journey and lairage durations had a significant effect on DOA. In particular, DOA showed an average increase of 26% in journeys between 2 and 3 h (IRR: 1.261) compared to journeys shorter than 1 h (reference category), and increased up to 40% for journeys longer than 3 h (IRR: 1.436) as compared to journeys shorter than 1 h. For example, for a lairage time less than 2 h, DOA is around 6% for the reference journey time (< 1 h) and 6% when the journey is between 2 and 3 h and 7% when it is more than 3 h. The mortality rate was approximately twofold higher when lairage was longer than 7 h (e.g. 5%–10%, IRR: 1.927), compared to a lairage shorter than 2 h (reference category). Additionally, a significant interaction between travel and lairage duration on DOA was identified and it was showed that a journey shorter than 1 h can significantly reduce 'dead-on-arrival' rate associated with a long lairage (Caucci et al., 2018).

The outcome table related to each process during pre-stunning is reported in Section 3.10 (Tables 8–21).

3.1.1. Arrival

Process description

Arrival of rabbits at a slaughterhouse is the first process of slaughtering and it takes place from the moment the truck arrives at the slaughterhouse until the moment the containers are unloaded from the truck.

The condition of rabbits on arrival represents the cumulative result of the state of animals on the farm including husbandry conditions, catching, crating of rabbits and transport in the truck.

Related hazards and welfare consequences

To understand the hazards and welfare consequences, three aspects must be considered:

- before being transported, rabbits may have been deprived of food (and sometimes water) for a variable duration
- rabbits arriving at the slaughterhouse have been submitted to transportation under variable climatic conditions, duration and conditions (e.g. stocking densities)
- rabbits should be unloaded from the truck as soon as possible but may remain some time under adverse climatic conditions on the truck before unloading.

This means that on arrival, rabbits may have been submitted to too high or too low effective temperature, insufficient space allowance and too long food and water deprivation (for detailed description of these hazards, see Section 3.6). Potential welfare consequences are cold or heat stress, restricted movements and/or prolonged hunger and thirst.

There is not much known about average travel durations for rabbits that go to slaughter. A review by Buil et al. (2004) suggests that in Spain, a single truck may stop in different farms to load rabbits before arriving at the slaughterhouse, hence not all rabbits have the same duration of transportation. Also, Luzi et al. (1992) conducted a survey in the Northern Italy studying pre-slaughter transports from farms located at different distances (25, 50, 100 and 150 km) over 1 year. They observed that the most critical conditions for rabbits are when they are transported over 4 h and at environmental temperatures above 18–20°C and a relative humidity of 70–75%.

Assessment of animal welfare

In the literature, the arrival is not distinguished from transport or lairage; therefore, no specific data are available for the arrival process.

What can be noted is that in Europe, according to the Council Regulation (EC) No 1099/2009, the Food Business Operator (FBO) has the overall responsibility for the welfare of animals from the time of arrival at slaughterhouse until the animals are dead. Based on this principle, assessment of the welfare status at the time of arrival can be considered an important first step in protecting animal welfare. The assessment protocol should enable the responsible person to decide on appropriate corrective actions for alleviating further negative welfare consequences or immediate stunning and slaughter of animals (as an ultimate intervention). The latter could be the case, for example, when a considerable proportion of rabbits on the truck show signs of heat stress.

The hazards identified at 'arrival', relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 18 (Section 3.10.1).

3.1.2. Unloading the truck

Process description

Unloading is the action of taking out the containers (or crates) with the rabbits from the truck and place them in the lairage area. Generally, the containers are unloaded rapidly either manually or mechanically using forklifts and are stored in the lairage area.

Generally, containers are placed on top of each other. To prevent lower level rabbits from being soiled by the urine and faeces of other rabbits, it is strongly recommended to use containers with solid floors.

The containers are arranged in spaced rows so that there is a passage allowing humans to move between the rows and observe the animals; this also allows air to circulate between the containers to ensure ventilation of the rabbits.

Commercial practices vary from unloading of animals and moving them straight to the point of stunning without lairage to holding them in lairage for some time. The study from Buil et al. (2004) in Spain indicated that 55% of the rabbits included in the survey were unloaded in the morning and the procedure lasted on average 23 $\pm$ 15 min. Cages were mainly (85%) unloaded in groups or in cage stands. In most of the cases (80%), the unloading zone was covered and protected from the wind. Veterinary inspections took place at that stage in all the 21 abattoirs included in the study.

Related hazards and welfare consequences

To minimise negative welfare consequences, animals should be unloaded as quickly as possible after arrival at the slaughterhouse. Containers must be in good condition without broken plastic or metal parts protruding inwards, which might cause injuries and bruises.

The hazard 'rough handling of the containers' can appear at this stage and lead to pain and fear.

Assessment of animal welfare

Welfare is not easy to assess at the unloading step. They include visible injuries and vocalisations.

The hazards identified at 'unloading', relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 19 (Section 3.10.1).

3.1.3. Lairage

Process description

According to the Council Regulation (EC) No 1099/2009, 'lairaging' means keeping animals in stalls, pens, covered areas or fields associated with or part of slaughterhouse operations. This definition is used worldwide.

The lairage is the period in between the entry of the animals in the lairage area (either on or off the truck) until they are taken out of the containers (which is the next process – handling and removing of rabbits from crates or containers). When unloaded, the containers are piled up in the lairage area where they can stay several hours.

The height of the container stacks, the space between the container and the protection and the ventilation provided inside the lairage area will impact directly thermal comfort and welfare of rabbits. The time that animals spent in lairage can also be a variable. Buil et al. (2004) performed a survey on rabbit transport in Spanish abattoirs from December 2003 to March 2004 to determine the parts of the process that most compromise the animal's welfare. Data were collected for the methods for loading, unloading, transporting, holding and slaughter. The survey involved 60 farms, 21 abattoirs and 21 hauliers. Lairage area were covered and half of them (n = 21) had forced ventilation system. The results from the same study indicated that rabbits were put in lairage area in the cage stands they were transported in (Buil et al., 2004). Only one abattoir used specific lairage cages which required transfer of animals from one cage used for transport to another in the lairage.

Petracci et al. (2010) conducted a study in order to assess the preslaughter conditions of rabbits in a commercial chain and to determine the effect of journey duration (short: < 220 min; medium: 220–320 min; long: > 320 min) and lairage duration (short: < 134 min; medium: 134–235 min; long: > 235 min) on mortality and carcass quality. They showed that long transport and lairage can impair mortality rate, slaughtering yields and carcass quality. Their study included 831 flocks (average of 2,207 rabbits/flock) of 9- to 12-week-old growing rabbits from 79 farms transported to slaughter at a major Italian abattoir in 2006.

Related hazards and welfare consequences

In the lairage area, temperature variations can be significant and depend on the time of day and the season. Due to this, rabbits can be submitted to too high or too low effective temperature, insufficient space allowance and too long food and water deprivation.

Assessment of animal welfare

The containers are arranged in spaced rows (Figure 4) so that there is a human passage to move between the rows and observe the animals, but also to allow air to circulate between the containers to ensure good ventilation of the animals. Animals stay at lairage usually several hours (see previous description) which allow FBO and official inspectors to inspect rabbits and assess welfare and health.

The hazards identified at 'lairage', relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 20 (Section 3.10.1).

3.1.4. Handling and removing of rabbits from crates or containers

Process description

Handling refers to removal of animals from the containers for the purpose of restraining, stunning and slaughter. Animals are removed individually from the cages by hand (Buil et al., 2004). Types of containers vary globally, ranging from traditional loose chicken crates to purpose-built rabbit transport modules. Rabbits are usually placed in transport crates originally designed for poultry (Figure 4).

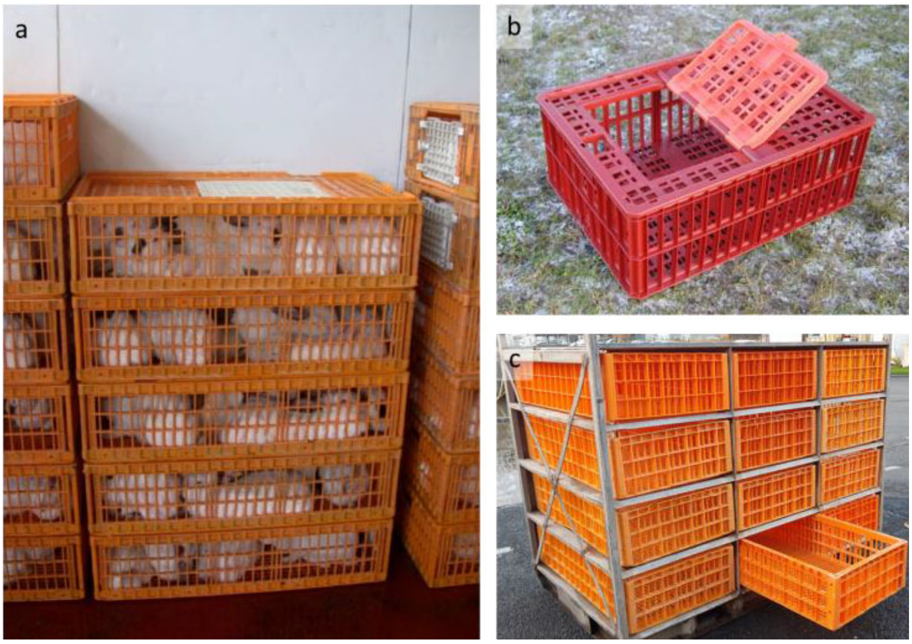


Figure 4: Common cages and containers used for the transport of rabbits: (a) Plastic cages with a sliding top and side opening, (b) Plastic crate with top opening or top and side opening, depending on model, (c) Containers with plastic drawers that slide (Source Credit Avipôle Formation)

Related hazards and welfare consequences

The design of some of these cages (Figure 4a and b) may cause animal welfare problems, as the opening for catching animals may be too narrow, increasing the risk of injury when handling the animal. Similarly, catching a rabbit that is located away from the openings can be difficult. The operator may resort to catching the animal roughly, by the head, neck or legs, increasing the risk of injury.

In addition to 'Rough handling of the rabbits during removal from containers', rabbits can be subjected to 'unexpected loud noise' due to the various activities going on in the slaughterhouse.

Assessment of animal welfare

At this stage of the process, rabbits that were dead on arrival (DOA) are removed, and rabbits that are visibly injured (e.g. with dislocated or broken bones) are killed.

The hazards identified at 'handling', their relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 21 (see Section 3.10.1).

3.2. Stunning methods for rabbits (phase 2): description and relevant welfare consequences

General background

The stunning phase includes stunning methods and associated restraint practices. Electrical and mechanical stunning methods require some form of restraint to facilitate proper application. Restraining practices vary according to the stunning method to facilitate effective application (European Commission, 2018), and the methods of restraints are described in the relevant section (Sections 3.2.1–3.2.3). Rabbits are mainly stunned by using head-only electrical or captive bolt stunning. Restraint applied for head-only electrical stunning aims to ensure the electrodes span the brain (illustrated under Section 3.2.1) and that applied for captive bolt stunning is intended to ensure proper placement and firing of the gun (illustrated under Section 3.2.3).

Council Regulation (EC) No 1099/2009 considers the main stunning methods to be reversible stunning methods (simple stunning). In this sense, these methods induce momentary loss of consciousness, and therefore, the onus of preventing recovery of consciousness following stunning relies solely on the prompt and accurate neck cutting, i.e. severing both carotid arteries in the neck supplying oxygenated blood to the brain. It is expected that the duration of unconsciousness induced by stunning should last longer than the sum of time interval between the end of stunning and neck cutting and the time taken to induce death through blood loss following neck cutting (Figure 5). The Regulation stipulates that both carotid arteries should be severed following stunning and rabbits should be confirmed dead before carcass processing.

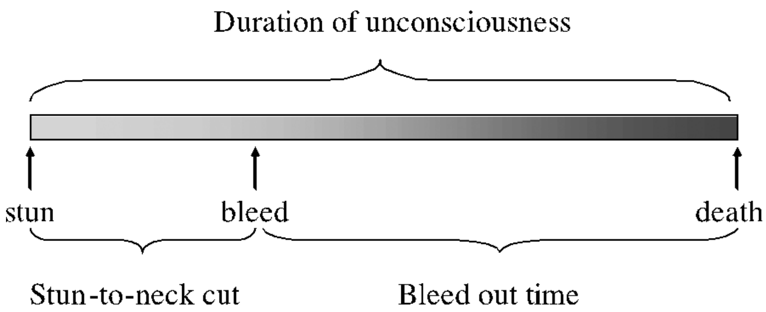


Figure 5: An illustration of the duration of unconsciousness required to be induced by a stunning method under humane slaughter conditions (EFSA, 2004)

Animals that are subjected to simple (reversible) stunning methods should remain unconscious until death occurs due to bleeding.

Related hazards and welfare consequences

The details of hazards and welfare consequences for each stunning method will be described in chapters 3.6 and 3.7. In general, we can state that hazards due to restraint may lead to negative welfare consequences, as conscious animals are severely restricted in their behavioural freedom whilst being stressed.

Regarding the stunning method, two categories of hazards exist. Firstly, the ones inducing negative welfare consequences during induction of unconsciousness (before animals lose consciousness). Secondly, the ones leading to delayed or failed onset of unconsciousness. Conscious rabbits have the capacity to receive, process and respond to information from the internal and external environment. Effective stunning leads to a brain state that is incompatible with this (EFSA, 2004). A failed stun leads to rabbits being conscious whilst exposed to hazards related to restraining, stunning and bleeding phase (e.g. being bled conscious). This is painful, fearful and distressing, and should be avoided.

Although direct scientific evidence is lacking, recovery of consciousness following effective stunning can be a painful process. For example, head-only electrical stunning of rabbits induces tonic–clonic seizures. The excessive contraction of the muscles could produce ecchymosis in muscle and can result in bone fractures.

Assessment of animal welfare

For these reasons, the rabbits should be checked to be unconscious following stunning. In addition, all animals should be checked again for unconsciousness just prior to bleeding. Various indicators can be used for this. They are described in Section 3.6.2 in a separate chapter, as the definition of indicators for monitoring of rabbit stunning was requested by the mandate from the EP.

3.2.1. Head-only electrical Stunning (including restraint)

Considerations regarding restraint

Restraining for head-only electrical stunning is manual and involves holding the rabbit with one hand supporting its belly, and the other hand guides the head into the stunning tongs or electrodes by holding its ears. Alternatively, an operator may hold both back legs of the rabbit with one hand, while the other hand holds the head and position it between the stunning tongs by guiding the ears (Figure 6).

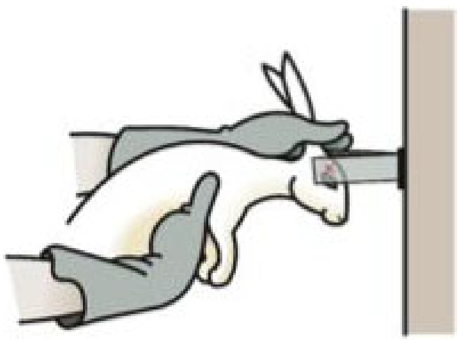


Figure 6: Illustration of head-only electrical stunning (Source European Commission, 2018)

As it can be seen in Figure 6, poor design of the electrode and/or wrong positioning of the head may result in the eyes of rabbits being injured (physical damage and sometimes rupture of the eyeball) before the onset of unconsciousness.

This does not occur when the electrodes are mounted on the ceiling (see Figure 7) where the rabbit body is supported with one hand and the other hand placed on its back to secure it in position for stunning (Figure 7).

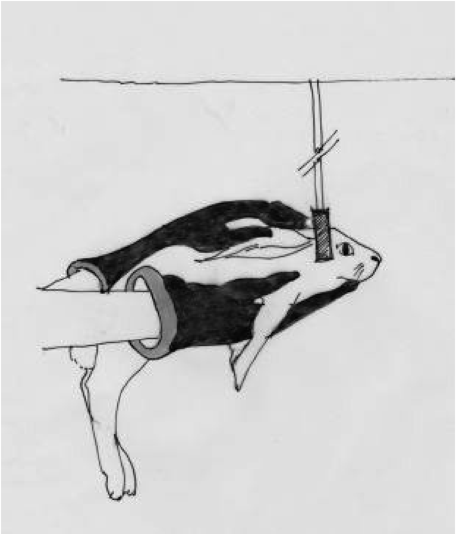


Figure 7: Head-only electrical stunning of rabbit (© Mohan Raj 2019)

In any case, rabbits should never be grabbed by the ears as it is considered painful (EFSA, 2005) and is forbidden by Regulation 1009/2009.

The fur on the rabbit's head may impede with the efficacy of electrical stunning due to high electrical resistance. However, wetting of rabbits' heads with a damp sponge will help to overcome electrical resistance. In addition to this, the electrodes must be cleaned at regular intervals using a wire brush to facilitate good electrical contact. These measures will prevent poor animal welfare outcome due to burning of fur which would occur due to generation of heat at the contact point of the electrode.

Process description

Head-only electrical stunning is widely used in commercial rabbit slaughter plants. To perform head-only electrical stunning, the head of the rabbit is positioned in handheld, wall-mounted or ceiling-mounted V-shaped electrodes which are firmly pushed between the back of the eyes and the base of the ears to span the brain (Figure 8) (Anil et al., 1998; Maria et al., 2001).

Figure 8: Types of electrical electrodes (Source: Federation of French Poultry Industries)

For electrical head-only stunning of rabbits, the European Commission recommendations based on best practices used in the EU rabbit slaughterhouses are a power of 100–117 V, a current of 140–400 mA, a frequency of 50 Hz and a duration of 1–3 s. However, Anil et al. (1998) showed that variations in impedance (resistance) of the rabbits' heads were considerable, due to their fur, and ranged from 300 Ω to more than 1,500 Ω. Owing to this, the amount of current delivered to rabbits also varied within treatment groups, ranging from 92–120 mA at 50 V, to 138–211 mA at 75 V, and 154–279 mA at 100 V. The authors recommended stunning rabbits with 100 V of a 50 Hz sine wave alternating current (AC) for one-second in order to deliver an average current of 140 mA. With these electrical stunning parameters, the average (S.D.) times (in seconds) to recovery were rhythmic breathing 35 (11), corneal reflex 26 (10) and response to nose prick 44 (18) s. Since stun-to-stick (bleed) interval practiced in slaughterhouses is less than 10 s, Anil et al. (1998) concluded that the recommended stunning parameters will prevent recovery of consciousness following slaughter.

Anil et al. (2000) recorded electrocorticograms (ECoGs) in eight commercial rabbits (1.7–3.1 kg) following the application of 100 V of a 50 Hz sine wave AC for 1 s. The results showed induction of typical epileptic activity in six rabbits, of which only two showed tonic/clonic seizures, the typical animal-based measure used to recognise the occurrence of a generalised epilepsy. The other four rabbits showed either high amplitude, low frequency or polyspike activities in the ECoG, and the authors concluded that these kinds of activities are also indicative of unconsciousness, and these animals were stunned but probably failed to manifest seizures due to exhaustion.

Related hazards and welfare consequences

During head-only electrical stunning, rabbits will be exposed to pain and fear due to incorrect handling during manual restraint or due to bad design of the electrode and consciousness leading to pain and fear, if poor electrical contact, too short exposure time, inappropriate electrical parameters or prolonged stun to stick interval occur.

Assessment of animal welfare

There is limited information available regarding suitable indicators for monitoring appropriate restraint and stun quality in rabbits stunned using head-only electrical stunning. Pain and fear due to incorrect handling can be assessed through escape attempts and vocalisations. As indicators of consciousness, the absence of tonic–clonic seizures, corneal or palpebral reflexes and the presence of breathing can be used. Also, vocalisation and spontaneous blinking can be included.

The hazards identified during electrical stunning, relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 22.

3.2.2. Controlled atmosphere stunning

Process description

Controlled atmosphere stunning (CAS) is not allowed in Council Regulation (EC) No 1099/2009 for rabbits, and is not listed in chapters 7.5 and 7.6 of the OIE guidelines. It was used in some EU countries before enforcement of the Council Regulation and it is presented in a limited number of research papers (Hattingh et al., 1986; Llonch et al., 2012; Nakyinsige et al., 2014; Dalmau et al., 2016).

CAS is applied to rabbits in the containers they arrive in at the slaughterhouse. Therefore, no handling of conscious rabbits is required. Shackling and handling are performed after the rabbits are stunned.

Rabbits are effectively stunned by exposure to concentrations of carbon dioxide at 70–98% and a mixture of 80% N_2 and 20% CO_2 (Llonch et al., 2012; Dalmau et al., 2016). During exposure to these gas mixtures, rabbits gradually lose consciousness. Rabbits exposed to at least 80% CO_2 will lose consciousness in on average 30 s, but to ensure enough duration of unconsciousness until death due to bleeding, they should be exposed to the gas concentration for at least 2 min. As gas stunning takes place in large batches (quantities), the interval between the end of exposure to the gas and sticking of the last rabbit is likely to be long compared to other stunning methods. Therefore, to prevent return of consciousness prior to sticking or during bleeding, the duration of unconsciousness induced with gas stunning needs to be longer than that required in e.g. electrical stunning situations.

Appropriate gas concentrations must be monitored continuously at the rabbit levels inside the chamber. Besides gas concentration and exposure time, other key factors to monitor are the temperature and humidity of the gas mixture.

Related hazards and welfare consequences (and indicators)

The hazards identified during gas stunning methods are: 'exposure to high CO_2 concentration', 'too short exposure time' and 'too low concentration of gas'. The latter two hazards can prolong consciousness and cause (respiratory) distress, pain and fear.

The rate of induction, depth and duration of unconsciousness induced with gas mixtures depend on both exposure time and gas concentration (see also Sections 3.5.2.6 and 3.5.2.11), and therefore, these are key parameters to control during gas stunning. Higher concentrations of CO_2 require shorter exposure times to induce a sufficient level of unconsciousness than lower CO_2 concentrations (Dalmau et al., 2016). However, exposure of conscious rabbits to more than 70% CO_2 causes painful stimulation of the nasal mucosa and aversive reactions. Rabbits will react with vocalisations, rubbing the nose with the forelimbs, headshaking and gasping (Llonch et al., 2012; Dalmau et al., 2016). Further research is needed to elicit the CO_2 concentration with the minimum aversion in rabbits.

Gasping is an indicator of respiratory distress, inherent to carbon dioxide stunning. It is perceived as an alarming or alerting response, but it also is associated with a reaction to unpleasant or painful inhalation of gas. On the other hand, Llonch et al. (2012) reported a higher percentage of rabbits gasping when exposed to 90% CO_2 than to 80% N_2 and 20% CO_2 (97 vs. 42%).

After some time, rabbits will lose posture, frequently accompanied by jumping or strong movements (which however should not be interpreted as escape attempts). Loss of posture and thus being unable to maintain body position indicates the moment of loss of consciousness (Dalmau et al., 2016). Llonch et al. reported that the mean latency to loss of posture during exposure to 80% N_2 20% CO_2 was 24.2 s and to 90% CO_2 it was 28.2 s. After loss of posture, when animals are unconscious, gasping will continue for some period and convulsions (uncontrolled muscular movements) can occur.

The hazards identified during gas stunning, relevant welfare consequences and related indicators, origin of hazards, preventive and corrective measures are reported in Table 23.

Assessment of animal welfare

At the end of controlled atmosphere stunning, rabbits should be checked at key stages for unconsciousness. Dalmau et al. (2016) reported that the state of consciousness after exposure to gas stunning can be assessed using indicators such as the presence of breathing, the presence of a corneal or palpebral reflex, vocalisations and the righting reflex.

Furthermore, after leaving the gas stunner, all animals should show the absence of muscle tone i.e. a complete relaxed body. In most cases, rabbits will be dead when exiting the CAS system. In these cases, it is important to ensure that all rabbits are dead before processing them. Death can be confirmed from the cessation of bleeding, permanent absence of breathing and a relaxed carcass. Additionally, the absence of heartbeat and dilated pupils can be used.

3.2.3. Mechanical stunning

Penetrating and non-penetrating captive bolt guns are routinely used to stun food animals (see EFSA, 2004 for details), including rabbits. The hazards identified during captive bolt stunning, relevant welfare consequences and related indicators, origin of hazards, preventive and corrective measures are reported in Table 24.

Considerations regarding restraint

For effective use, the animal should be restrained in sternal recumbency on a level surface by gripping its shoulder to allow accurate positioning of the gun. Restraint of the animal and proper presentation of its head may be difficult if rabbits are excited and struggling. As the skin is only loosely attached to the skull, the muzzle of the gun may shift after having been correctly positioned.

Penetrative captive bolt stunning

Process description

The penetrating captive bolt is designed to cause a combination of concussion and destruction of brain tissue. Following penetration, skin and bone fragments can act as secondary missiles, which can cause further damage to the brain, crushing tissues and blood vessels. When the bolt retracts, it leaves a temporary void in the cavity created by its passage and promotes further tearing of axons and blood vessels. This latter effect may be strengthened by increased intracranial pressure due to haemorrhage. Since there is haemorrhage, there will be reduced blood supply and, in this situation, the brain could be starved of oxygen and unconsciousness would be sustained.

Spring and cartridge (0.22 and 6 mm calibre blank) operated penetrative captive bolt guns are effective in inducing unconsciousness in rabbits (Dennis et al., 1988). It renders the animal unconscious by firing a bolt through the skull and into the brain. After firing, the bolt retracts into the gun. As death cannot be guaranteed after penetrative captive bolt, it must always be followed by bleeding as soon as possible severing both carotid arteries (Schütt-Abraham et al., 1992a).

Several factors determine the outcome of captive bolt stunning, importantly, the site and angle of shooting bolt diameter, penetration depth and bolt velocity (EFSA, 2004).

Stunning effectiveness depends mainly on the site of impact. For long-lasting effective stun, the bolt should be placed directly on the skull at the intersection of lines drawn from the lateral canthus of each eye to the opposite ear, aiming towards the medulla oblongata (Figure 9). In this position, the impact will damage both cortex and brain stem. Positioned between the eyes, the bolt would penetrate the olfactory bulb if applied at the sagittal suture and enter the ocular orbit if applied paramedially, while positioned further rostrally it would hit the nasal cavity. These positions will cause ineffective stun or short-lasting concussion, and a lot of pain. The angle of firing the bolt should also be perpendicular to the skull bones, otherwise, the bolt may slide or skid due to the presence of loose skin and hair. While using penetrating captive bolt, the angle of firing also determines the parts of the brain damaged by the bolt, and hence the outcome.

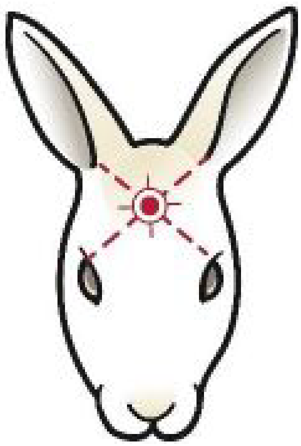


Figure 9: Bolt position at the intersection of lines from each eye to the opposite ear (Source European Commission, 2018)

According to Karger (1995), the captive bolt diameter is critical because an important factor in determining effectiveness is the product of mass of the bolt and acceleration force applied to the head, and hence, the brain. The maximum acceleration force impacted on the head would be expected when the mass of impacting bolt is at least equivalent to that of the head and the velocity is high. By contrast, a bolt with a very small mass and a very high velocity, will result in perforation of the skull without significant damages to the brain. Owing to this, penetration of a narrow bolt into the brain tissue may not always produce loss of consciousness due to brain concussion. The cartridge power or air pressure of the stunner should be appropriate for the animal. If applied in the correct position, a spring operated penetrative captive bolt gun with a 5 mm diameter and 27 mm deep bolt may be appropriate to induce effective stunning in all rabbits (Schütt-Abraham et al., 1992b). However, the European Commission suggested a minimum bolt diameter of 6 mm (European Commission, 2017 Study on best practices and European Commission, 2018 factsheets). The depth of penetration is another crucial factor and it should be deep enough to impart forces to the brain stem, since this is where the vital functions, such as breathing and cardiovascular activity, are regulated (Laureys, 2005). In addition, if brain damage is insufficient or the bolt does not reach the relevant structures (either because of insufficient penetration depth, placement or orientation), the animal may remain conscious or show a shallow depth of concussion. In other words, traumatic brain injury alone is not sufficient on animal welfare grounds.

If re-stunning is necessary, the second stun should be done using electrical methods, as it would be difficult to know where to repeat the shot on the damaged skull.

Related hazards and welfare consequences

During penetrative captive bolt stunning, rabbits can be exposed to pain and fear in case of incorrect handling during manual restraint and consciousness leading to pain and fear, if incorrect shooting position and angle, incorrect bolt diameter, incorrect penetration depth, incorrect bolt velocity or prolonged stun to stick interval occur.

Assessment of animal welfare

There is limited information available regarding suitable indicators for monitoring appropriate restraint and stun quality in rabbits stunned using penetrative captive bolt. Pain and fear due to incorrect handling can be assessed through escape attempts and vocalisations. As indicators of consciousness, the presence of corneal or palpebral reflex, the presence of rhythmic breathing and the absence of immediate collapse can be used. In addition, vocalisation and spontaneous blinking can be assessed (further details about indicator selection, specificity and sensitivity are referred to in Section 3.6.2).

Non-penetrative captive bolt stunning

Considerations regarding restraint

Rabbit can be restrained on a non-slippery surface with a backstop so it cannot back away. One hand is holding its neck and shoulder such that the ears are tucked away from the head, and the gun is operated with the other hand. Illustrations of restraint and shooting position are presented below (courtesy of the European Commission Factsheet).

Process description

It has been known that shooting of a non-penetrating captive bolt on the frontal/parietal bones of animals causes acceleration and deceleration of the head, creating rotational and shear forces in the brain, leading to brain concussion and unconsciousness. Effective application of a non-penetrative captive bolt (e.g. mushroom shaped) powered by cartridge, compressed air or spring on the frontal/parietal bones of animals and delivery of a sufficient blow to its head leads to immediate loss of consciousness due to brain concussion. The captive bolt gun should be placed firmly behind the eyes and in front of the ears and fired perpendicular to the skull bones (Figure 10). Non-penetrative captive bolt must always be followed by bleeding as soon as possible severing both carotid arteries (Schütt-Abraham et al., 1992a).

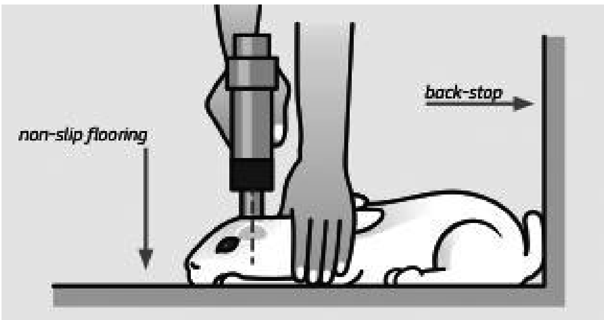


Figure 10: Restrain and position for captive bolt stunning (Source European Commission, 2018)

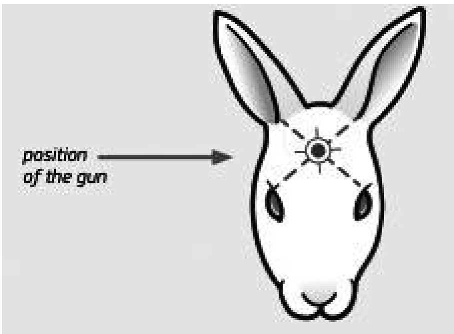


Figure 11: Position of the gun (Source European Commission, 2018)

The operator should take into consideration some of the important variables, such as age of the animal, development and thickness of skull bones, during the selection of power of cartridge or compressed air pressure, that determine the animal welfare outcomes.

Published data on the use of non-penetrative captive bolt in rabbits are scarce. Nevertheless, one study (Walsh et al., 2017), involving the use of a commercially available gun operated by using compressed air and with a bolt extension of 2 cm beyond the muzzle of the gun (Zephyr-E, Bock Industries, Philipsburg, PA, USA) provides some data on its effectiveness.

Walsh et al. (2017) carried out a preliminary study using rabbit cadavers of varying sizes and ages and weighing between 0.9 and 4.7 kg to determine the appropriate shooting position and required air line pressure for this device. The correct location and pressure were determined by dissection of the head following application of the device looking for maximum brain damage without breaking the skin or injuring other anatomical sites. The results indicated that the appropriate pressure for sufficient brain trauma and skull fractures was 621 kPa (90 psi) for adult rabbits (> 12 weeks old), 483 kPa (70 psi) for growers (6–12 weeks old), and 379 kPa (55 psi) for pre-weaned kits (150 g and larger, ≤ 5 weeks old). A minimum pressure of 345 kPa (50 psi) is needed for this device to discharge.

Further evaluation of this device was carried out on three farms using 63 New Zealand White-like rabbits of different ages and the results showed 100% success rate. It should be noted that, according to the authors, although a single shot appeared to be sufficient to render rabbits unconscious, the experimental animals used in this study were shot twice in quick succession. In a personal communication, one of the authors (Prof. Patricia Turner) reassured that a single shot fired using this gun is sufficient to render rabbits unconsciousness and the equipment is being used in commercial rabbit slaughterhouses in Canada. The authors attributed the success rate to the effective restraint during the application.

Related hazards and welfare consequences

During non-penetrative captive bolt stunning, rabbits will be exposed to pain and fear due to incorrect handling during manual restraint and consciousness leading to pain and fear, if incorrect shooting position and angle, incorrect bolt diameter, incorrect bolt velocity or prolonged stun to stick interval occur.

Assessment of animal welfare

There is limited information available regarding suitable indicators for monitoring appropriate restraint and stun quality in rabbits stunned using non-penetrative captive bolt. Pain and fear due to incorrect handling can be assessed through escape attempts and vocalisations. As indicators of consciousness, the presence of corneal or palpebral reflex, the presence of rhythmic breathing and the absence of immediate collapse can be used. In addition, vocalisation and spontaneous blinking can be assessed (further details about indicator selection, specificity and sensitivity are referred to in Section 3.6.2).

Percussive blow stunning

Considerations regarding restraint

Rabbit can be suspended upside-down by firmly holding both its hind legs, or restrained on a non-slippery surface with a backstop so it cannot back away. In the latter case, one hand is holding its neck and shoulder such that the ears are tucked away from the head.

Process description

A percussive blow is delivered on the head just in front of the base of the ears (similar to captive bolt stunning) in the case of stunning on a solid surface. For stunning rabbits that are suspended by the hind legs, the blow is aimed behind the ears. The blow is delivered with an iron rod, pipe or a wooden club, with sufficient force to render the animal immediately unconscious due to brain concussion. Some animals may be killed if the blow is too severe, which is not a welfare problem. However, as death cannot be guaranteed after percussive blow, it must always be followed by bleeding as soon as possible severing both carotid arteries.

According to European Commission (2018), rabbit should be suspended upside-down and deliver the blow on top of its head, just behind the ears. The aim is to deliver the blow to the occipital region of the skull. A potential problem is that the ears may get in the way and hinder the delivery of an effective blow.

Effective stunning of rabbits with a percussive blow induces reversible loss of consciousness (simple stunning), and therefore, the onus of preventing recovery after stunning relies on the prompt and accurate exsanguination.

Related hazards and welfare consequences

During percussive blow stunning low force application, wrong hitting position or prolonged stun to stick interval may occur. In still conscious animals, this may lead to pain and fear due to manual restraint and inversion.

The hazards identified during percussive blow stunning, relevant welfare consequences and related indicators, origin of hazards, preventive and corrective measures are reported in Table 25.

Assessment of animal welfare

There is limited information available regarding suitable indicators for monitoring appropriate restraint and stun quality in rabbits stunned using Percussive blow. Pain and fear due to incorrect handling can be assessed through escape attempts and vocalisations. As indicators of consciousness, the presence of corneal or palpebral reflex, the presence of rhythmic breathing and the absence of immediate collapse can be used. In addition, vocalisation and spontaneous blinking can be assessed.

3.3. Description of bleeding (phase 3) and relevant welfare consequences

General consideration on process description

This phase includes bleeding of the rabbits following stunning (to induce death of stunned animals), and bleeding during slaughter of rabbits without stunning. These processes are described in the following Sections 3.3.1 and 3.3.2. The outcome tables related to each process are reported in Section 3.10 (Tables 26 and 27).

In this phase, animals should first be checked to be unconscious (at the end of stunning) through the assessment of indicators of consciousness (indicated in stunning section).

In the case of bleeding following stunning, both the carotid arteries should be severed swiftly to prevent recovery of consciousness. Under commercial slaughterhouse conditions, rabbits are stunned individually and shackled, and neck cutting is performed immediately by making an incision ventrally, behind the mandibles. Both the carotid arteries must be severed according to the Council Regulation (EC) No 1099/2009. The stun-to-stick interval is short when compared with other animals slaughtered for human consumption. For example, a survey carried out in a rabbit slaughterhouse located in Northern Italy revealed that the average stun-to-stick interval was 5.5 (S.D. 0.88) s (Nodari et al., 2009), and a range of 5–10 s being the norm, and an exceptional case of 20 s, in Europe (European Commission, 2017). The effectiveness of stunning should be monitored to ensure animals do not recover consciousness before death.

Assessment of animal welfare

It is important to assess the consciousness and the death of rabbits after bleeding and before being processed. Live rabbits can be recognised from the presence of breathing or of the corneal and palpebral reflexes, pupils that are not fully dilated, continued bleeding or the presence of muscle tone and body movements (EFSA AHAW Panel, 2013b).

3.3.1. Bleeding following stunning

Specific process description

In conventional electrical stunning systems, the duration of unconsciousness last for 22 s (Anil et al., 1998, 2000). Therefore, effectively stunned animals should have both carotid arteries cut as soon as possible, but within 10 s (European Commission, 2018). In practice, this means that the stun-to-stick interval ranges from 5 to 10 s in case of electric stunning, and in exceptional cases could last to 20 s (European Commission, 2017).

Related hazards and welfare consequences

If animals are conscious during bleeding due to ineffective stunning application or prolonged stun-to-neck cutting interval after reversible stunning applications, the risk of suffering increases. First, the incision made in the neck involves substantial tissue damage in areas well supplied with nociceptors (Kavaliers, 1989). The activation of the protective nociceptive system induces the animal to experience pain. Second, death due to sticking is not immediate and there is a period of time during which the animal is still conscious and can feel fear, distress, pain and other types of suffering (EFSA AHAW Panel, 2013c–f).

During bleeding following stunning, rabbits can be exposed to consciousness leading to pain and fear due to prolonged stun-to-neck-cut interval and incomplete sectioning of carotids. The rabbits that are ineffectively stunned or those recovering consciousness can be exposed to pain due to neck cutting, and eventually repeat cuts and stimulation of the wound. These rabbits will also experience pain, fear and distress when bled to death and if they are processed alive.

The hazards identified during 'bleeding following stunning', relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 26.

3.3.2. Bleeding during slaughter without stunning (including restraint)

Although slaughter without stunning of rabbits is practiced, scientific evidence is scarce. Nakyinsige et al. (2014) and Lopez et al. (2008) state that for slaughter without stunning, rabbits are shackled prior to neck cutting. There are no published sound scientific data on how neck cutting is performed or the associated welfare consequences, in particular regarding the times to loss of consciousness or onset of death.

The following paragraphs are based on expert opinion and informal contact with food business operators. The experts' opinion comes from the knowledge of other species such as poultry, cattle and sheep (EFSA, 2004).

Specific process description

Slaughter without stunning results in gradual loss of consciousness and onset of death through blood loss. This killing method may be performed on individual rabbits restrained manually or on animals that have been shackled on a moving metal shackle line. Since rabbits are conscious during slaughter, the risk of suffering increases in three respects: a) restraint, b) incision of the neck and c) gradual onset of unconsciousness and death.

Related hazards and welfare consequences

During restraint

Catching and robust restraint of conscious animals for neck cutting causes pain, fear and distress, especially when animals are hung upside-down by the legs in shackles. Other less stressful restraining methods include the placement of the rabbit in a cone, manually by a person holding both of their legs or in lateral recumbence (Von Holleben et al., 2010). In all cases, restraint must be as short as possible. Animals must be restrained only when slaughter can be performed without any delay. The restraining device must suit the size and species and type of rabbits slaughtered and must not cause injuries. The restraint must be such that it provides good access to the neck for effective neck cutting and bleeding out.

During incision

The incision made in the throat to sever blood vessels involves substantial tissue damage in areas well supplied with high density of nociceptors. The activation of the protective nociceptive system induces the animal to experience severe pain. There are factors that can increase the pain perception, such as performing multiple cuts (more nociceptors are affected), changes of direction of the cut, blunt knife (extension of the lesion), insufficient length of the knife, wound manipulation or presentation of the neck in a position disturbing a good cut or flow of the blood (i.e. increased flexibility of the skin due to insufficient tension) (Von Holleben et al., 2010).

During gradual onset of unconsciousness and death

Onset of unconsciousness and death due to bleeding are not immediate. Rabbits are gradually rendered unconscious as brain perfusion becomes insufficient to sustain normal function. Neither the time to onset of unconsciousness nor the time to onset of death in rabbits slaughtered without stunning is reported in the literature. Nevertheless, while bleeding during slaughter without stunning, the wound site must remain open to enable profuse bleeding, while preventing further stimulation of the wound (such as physical contact or scraping) during the conscious period. As many factors may lead to poor welfare, continuous and systematic monitoring any sign of life before carcass dressing begins is required.

The hazards identified in the case of 'bleeding during slaughter without stunning', relevant welfare consequences and related indicators, hazards' origins, preventive and corrective measures are reported in Table 27.

3.4. Emergency killing

Council Regulation (EC) No 1099/2009 defines 'emergency killing' as the killing of animals which are injured or have a disease associated with severe pain or suffering, and where there is no other practical possibility to alleviate this pain or suffering.

Emergency killing should be carried out when rabbits are in severe pain or suffering. Conditions that will induce severe pain and suffering are e.g. fractures, bone dislocations and open wounds. The rabbit suffering from severe pain will be detected when the container will be open at the moment of the handling of the animals. When the animal is fit for consumption, then it should be proceed normally since the process immediately after handling is stunning (therefore rendered inconscious) before shackling. When the animal is not fit for consumption, the responsible person should ensure that slaughter plant has procedures, facilities and equipment for killing these animals outside the normal slaughter line immediately after animal was identified. The methods used can be mechanical methods or electric stunning followed by bleeding, depending on the condition of the animal.

3.5. Response to ToR-1: hazard identification, origin and specific preventive and corrective measures

According to EFSA AHAW Panel (2012a), a hazard is any aspect of the environment of the animal in relation to housing and management, animal genetic selection, transport and slaughter, which may have the potential to cause poor welfare.

In this opinion, hazards have been identified through the activities described in Section 2.2 and analysed for each phase and process under consideration. The hazards listed in the following sections are related to conscious animals.

According to the mandate, the possible origin of the hazards, in terms of facilities/equipment or staff, should also be identified. When discussing these categories, it was agreed that the 'origin' can be explained further by detailing what actions from the staff or features from equipment and facilities can cause the hazard.

Therefore, for each 'origin category' (facilities/equipment, staff), relevant explanations (so-called 'origin specifications') have been specified.

The mandate also requests for preventive and correctives measures regarding the different hazards identified. Quite often, mainly in stunning and bleeding phases, correctives measure do not exist (i.e. too long food deprivation). In this case, mitigation measures regarding welfare consequence can apply (i.e. slaughter the animals as soon as possible) and they will be described in ToR3 chapter 3.7. For all the cases when preventive and corrective measures exist: i) if they are specific to a particular hazard, they will be described here under each hazard part; ii) if they are general measures addressing different hazards, they will be described under Section 3.7 in ToR3.

The list of the identified hazards with relevant origin categories and origin specifications are reported in the outcome tables (Tables 18–27, Section 3.10: first column – hazards, third column – origin category, forth column – origin specification). In addition, considering that each hazard may lead to one or more negative consequences on the welfare of the animals, the outcome tables also report the welfare consequences each hazard is associated with (second column of the outcome tables mentioned above).

The hazards that have been identified in the context of rabbit slaughtering have been grouped into three main categories, by phases of slaughtering: a) during the pre-stunning phase, b) during the stunning phase and c) during the bleeding phase.

The full list of hazards, with their definitions and indication of which process of slaughtering they apply to, are reported in the following sections.

3.5.1. List of hazards during Phase 1 – pre-stunning

3.5.1.1. Too high effective temperature

Definition

The effective temperature perceived by an animal is the combination of the temperature, the humidity and the ventilation or air speed. In hot and humid environmental conditions, poor ventilation will exacerbate the perceived temperature. When the effective temperature is too high (above their thermoneutral zone-15–25°C and 60–65% humidity; DEFRA, 2005; Verga et al., 2007, see Table 7), the thermoregulatory capacities of the rabbits for homoeothermy are exceeded and they show difficulty achieving a balance between body heat production and body heat loss which lead to heat stress (for details about welfare consequences, see Section 3.6.1).

A survey conducted in Northern Italy on pre-slaughter transports suggested that the most critical conditions for rabbits are when they are transported over 4 h and at environmental temperatures above 18–20°C and a relative humidity of 70–75%. (Luzi et al., 1992).

Processes of slaughtering to which this hazard applies: arrival and lairage.

Thermal stress at lairage can be a consequence of poor transport conditions, from which animals have to recover and lairage conditions themselves.

Hazard preventive and corrective measures

In the lairage, temperature variations can be significant and depend on the time of day and the season. Temperature and humidity can be registered at the crate level and recording systems can monitor the climatic conditions in the area and allow alarm warning when the values are outside the thermoneutrality zone of the rabbit (15–25°C and 60–65% humidity; DEFRA, 2005; Verga et al., 2007, see Table 7). In case of high temperature, the slaughterhouse must have cooling systems (rooftop, mechanical or static ventilation) and at a minimum, it is advisable to increase the spacing between the rows of containers. In cold weather, it is advisable to tighten the rows of containers to limit drafts without preventing the circulation of employees between crates. It is also advisable to ensure that the doors of the waiting area are properly closed.

One of the most important climatic components that influence the welfare of farmed animals is the ambient temperature.

Table 7: Optimal ambient temperatures (and relative humidity) for indoor housing of rabbits (Verga et al., 2007)

	Ambient temperature (°C)	Relative humidity (%)
Breeding females (does)	16–21	60–70
Breeding males (bucks)	12–16	60
Growing rabbits (early weaned rabbits)*	15–20 (20–22)*	60–70

*: EFSA (2005).

Avoiding the hottest hours of the day for transportation of animals will allow them not to experience extremely warm climatic conditions, which are especially problematic when trucks are not equipped with ventilation systems (Verga et al., 2009). Close environmental control in the crates or modules on the vehicle is difficult, mainly because ventilation is passive on most vehicles and is impeded by the close stacking of adjacent crates. When lorries are full of rabbits, the ventilation inside tends to be poor so rabbits on the inside of a load may suffer hyperthermia. Furthermore, the rabbits transported in summer rather than in winter showed signs of severe heat distress and more dehydration. Nevertheless, the same authors observed that winter transport increased muscle activity as evidenced by the lower liver and muscle glycogen concentration. Rabbits placed in the middle and bottom of crate stacks showed higher levels of some stress indicators (blood glucose and corticosterone) than those located at the top floor without regard to journey length.

At arrival, when there is a too high effective temperature animal should be protected from the sun or unloaded immediately from the truck.

At arrival and lairage, in order to check if effective temperature is still above thermoneutral zone, temperature and appropriate indicators should be measured (for detail see Section 3.6.1), then ventilation should be provided.

At lairage, in hot climatic conditions, in addition to ventilation, space between the piles of container should be increased to ensure good circulation of air at rabbit level.

These measures (ventilation, protection from the sun) can be used separately or in combination, depending on how critical the situation is. They can act as preventive measure, but if not applied first, can be acting as corrective measures for the hazard and the welfare consequence (heat stress, see Section 3.6.1).

3.5.1.2. Too low effective temperature

Definition

The effective temperature perceived by an animal is the combination of the temperature, the humidity and the ventilation or wind speed. In cold and humid environmental conditions with high wind speed, the perceived temperature will decrease rapidly. When the effective temperature is too low, the thermoregulatory capacity of the rabbits for homoeothermy is exceeded. Rabbits can die from hypothermia if the conditions are too cold or the rabbits are wet and cold (Petracci et al., 2010).

Progressive fall in ambient temperature induces bradycardia in rabbits and abnormalities induced by hypothermia are detectable in electrocardiograms (ECGs) at −12°C and they become more pronounced at −15°C (Kour et al., 2015).

Processes of slaughtering to which it applies: arrival and lairage.

Hazard's preventive and corrective measures:

Some preventive measures should be taken at the time of transportation:

Avoiding coldest hours of the day for transportation of animals will allow them not to experience too extremely cold climatic conditions, which are especially problematic when trucks are not equipped with curtains (EC Reg 1/2005[2]). In very cold climatic conditions, in order to avoid too low effective temperature at the level of rabbits, curtains should be installed on the truck to allow rabbits to stay in their thermoneutral zone.

Petracci et al. (2010) showed that during seasons when the external temperature was cold e.g. < 0°C, closing the ventilation openings in the front and top of the trailer and providing curtains reduced the risk of DOA, especially in loads containing wet and cold rabbits. However, the WG experts felt that an insufficient space allowance could in itself lead to negative welfare consequences (see Section 3.5.1.3).

At arrival and lairage, if effective temperature is still below thermoneutral zone (can be checked by measuring temperature and appropriate indicators – for details see Section 3.6.1), then adequate shelter should be provided to protect rabbits from the wind.

At lairage, in cold weather, it is advisable to reduce the gap between the rows of containers to limit draughts without preventing the movement of employees between crates. It is also advisable to ensure that the doors of the waiting area are properly closed (Bourin, personal, 2019). To prevent rabbits from being outside their thermoneutral zone, or when they are, to correct the hazard leading to cold stress, closed shelter with heating should be provided at lairage.

These measures (protection from wind, unloading quickly and placing in lairage) can be used separately or in combination, depending on how critical the situation is. They can act as preventive measure, but if not applied first, can be acting as corrective measures for the hazard and the welfare consequence (cold stress, see Section 3.7.1.1).

3.5.1.3. Insufficient space allowance

Definition: The space allowance is the space that an animal disposes once it has been placed in the container. In the case of rabbit, the space allowance corresponds to what is perceived by the animal, and the more it is reduced, the less the animals have the possibility to sit or lie together or change position. This space will not change since the placement in the container will last until the time when the rabbits will be removed from the container to be stunned. The space allowance is directly linked to the stocking density in containers, which is usually expressed in number of animals, area (cm2) per kg body weight or live weight in kg/m^2.

Caucci et al. (2018) performed a retrospective analysis of 6,411 fattening rabbit batches and 450 breeding rabbit batches transported in a 3-year period to an Italian abattoir. The stocking densities found in this survey ranged from 346 cm^2/kg (28.9 kg/m^2) to 108 cm^2/kg (92.6 kg/m^2). Low stocking densities referred to a space allowance above 178 cm^2/kg (under 56.2 kg/m^2) and high-stocking densities to a space allowance below 162 cm^2/kg (above 61.7 kg/m^2). The highest number of batches at high stocking density was found in winter (61% of all batches). Batches with high stocking density showed a higher DOA rate even in winter, suggesting that the reduction of space availability does not protect against negative effects of low temperatures.

Processes of slaughtering to which it applies: arrival and lairage

Hazard's preventive and corrective measures:

According to Defra guidelines (DEFRA, 2005), the stocking density (which is directly linked with the space allowance) should be adjusted according to:

- The temperature/humidity combination.
- Module or crate (containers) design.
- Trailer design, whether curtain-sided or open-sided. If the performance of a trailer in hot weather is not known, under-stock until experience is gained.

[2] Annex I, Chapter VI, point 3. Ventilation for means of transport by road and temperature monitoring.

Regarding these elements, the only preventive measure for insufficient space allowance is to adjust the number of rabbits to the size of the containers. No corrective measures exist for this hazard, but only mitigation of the welfare consequences (see Section 3.6.1).

3.5.1.4. Food deprivation for too long

Definition: Food deprivation occurs when rabbits have no access to food for some hours, leading to hunger, and, in the case of prolonged negative energy balance, difficulties coping with other hazards such as low temperature, loss of weight, etc.

Humans experience different phases of hunger. Initially, there is an enthusiasm for food, but as time progresses hunger changes to gnawing emptiness whilst feeling weak, lethargic and more sensitive to cold. It is very likely that other monogastric animals experience these phases. In these animals, hunger is partly initiated by a drop in the glucose utilisation rate in specific cells in the liver and the brain. This drop is assumed to correspond to a fall of at least 5% in the resting blood glucose levels (in rats). In the absence of food, animals will metabolise glycogen stored in the muscle and liver to meet energy demands. If food deprivation continues, the lower blood glucose levels activate sympatho-adreno-medullary system, which stimulates the lipolysis and the triglycerides stored in fat are released into the blood circulation as free fatty acids (FFAs). The FFAs act as an alternative to glucose as energy source (Gregory, 1998). Inevitably, if hunger continued beyond this metabolic state, animals will go into a state of catabolism utilising protein as a source of energy.

During the period lasting between catching at the farm and slaughter at the abattoir rabbits are kept without feed and water. Moreover, feed can be removed before rabbits are caught and crated on the farm to allow time for the evacuation of the intestinal contents. This practice may contribute to reducing the incidence of faecal contamination of the carcass which may occur during gastrointestinal tract removal as well as reducing stress during transportation. In this case, fasting should be referred to the total length of time rabbits are without feed before processing including the time the rabbits are on the farm without feed, as well as the time rabbits are in transport and in the lairage area at the processing plant (Verga et al., 2009). Time of food deprivation is important because it affects animal welfare. Rabbits lose 3–6% of body weight during the first 12 h of fasting, increasing to about 8–12% at 36–48 h (Cavani and Petracci, 2004). Generally, weight loss is slightly lower if fasted rabbits are allowed access to water before crating (Ouhayoun and Lebas, 1995). In the first 4–6 h, weight loss in rabbits is mainly due to emptying of the gut (Lambertini et al., 2006).

Processes of slaughtering to which it applies: mainly arrival and lairage but of course rabbits will be submitted to this hazard until they get unconscious.

Hazard's preventive and corrective measures:

To prevent this hazard, the food withdrawal should be done according to transport time and the lairage time. It is recommended that on farm withdrawal plus duration of transportation plus lairage time, should not exceed 12 h. This can be achieved by planning carefully these phases and schedule and prioritise slaughtering of animals. The only existing corrective measure is providing food and water to animals.

3.5.1.5. Water deprivation for too long

Definition: Rabbits have no access to water for some hours, leading to thirst and, with prolonged dehydration, difficulties in coping with high temperatures etc. Water deprivation time is the result of the time between the drinkers' removal on-farm and the catching of animals plus the transportation time and waiting time before unloading on arrival. It will be extended further during lairage. When one or more of these times is too long, it leads to too long water deprivation.

Thirst is an intrinsic response to dehydration, triggered by two physiological factors – volumetric and/or osmotic stimuli. Thirst occurs either when there is a fall in blood volume or when the tonicity of the of interstitial fluid increases. An example where both occur together is when animals do not have access to water during hot weather with the worst animal welfare consequences. The average normal water intake for rabbits is 50–150 mL/kg body weight daily.

In domestic rabbits, there is a close relationship between levels of solid food and drinking water intake. It has been shown that the quantity is about twice as much as the dry matter consumed. In addition, rabbits with water restrictions eat little and their growth is impaired (Prud'Hon et al., 1975).

Prud'Hon et al. (1972) showed that water consumption varied by a factor of 2 depending on the animal: from 134 to 284 g per day for rabbits at the end of their growth weighing between 4 and 5 kg. Prud'Hon et al. (1975) also demonstrated that after one week of adaptation rabbit receiving free access to drinking water during only 10 min per 24 h have a feed intake reduced by 86–76% of that of the ad libitum drinking rabbits, depending of the age: 86% for 6–9 weeks old rabbits, 84% for 11–14 weeks old ones and 76% for adults.

Processes of slaughtering to which it applies: mainly arrival and lairage but of course rabbits will be submitted to this hazard until they get unconscious.

Hazard's preventive and corrective measures:

To prevent this hazard, rabbits should have access to water until catching. It is recommended that on-farm withdrawal plus duration of transportation plus lairage time, should not exceed 12 h. This can be achieved by planning carefully these phases and schedule and prioritise slaughter of animal. The only existing corrective measure in providing water to animals.

3.5.1.6. Rough handling of containers

Definition: Moving mechanically or manually the containers resulting in tilting, dropping or shaking. This hazard can occur at any time the containers will be moved, e.g. when unloading from the truck and when moving from lairage to the stunning point.

Injuries can be inflicted during unloading of containers at the abattoir, but there is no published data on the incidence of this hazard or the welfare consequences in rabbits.

Process of slaughtering to which it applies: unloading from the trucks, movement containers from lairage to the point of removal of rabbits for stunning.

Hazard's preventive and corrective measures:

Unloading should be performed smoothly and in a horizontal position to prevent tilting of containers that causes rabbits to pile up or bunch. This can be achieved by a good training of the staff about how to handle the containers and how to properly use the forklift or manual trolley for it. The good maintenance of the facility and the equipment will allow to have a forklift functioning smoothly on an even floor that will lead to proper handling. When rough handling has been performed, there is no corrective measure for this hazard.

3.5.1.7. Unexpected loud noise

Definition: A noise that by its level suddenly induces fear to animal.

A slaughterhouse is an environment with loud noises originating mainly from machines and manipulation or movement of containers and sometimes from personnel shouting. It is important to limit unexpected loud noises that will lead to fear and decrease coping capacities. Rabbits can be subjected to noise in all the processes of slaughtering, but it is of main concern during pre-stunning phase and, in particular, during the lairage because this is the stage in which the rabbits stay longest. In fact, during the stunning and bleeding phases, rabbits are expected to be unconscious and therefore not affected by unexpected loud noises. On the other hand, if they are conscious in these phases, they will experience additional major hazards (e.g. being bled conscious) that will lead also to pain and fear. There is no available data on the noise level that will imply welfare consequence.

Process of slaughtering to which it applies: lairage

Hazard's preventive and corrective measures:

The preventive measure will consist in staff education and training: i) to make them aware that the noise should be avoided and ii) to make them avoid shouting, making noise with the machines/containers and identify and eliminate the sources of noise. Regarding facilities and equipment: the machine should be settled correctly to avoid excessive noise and the facilities should be noise proofed. Once the noise has been emitted, there is no way to correct the hazard but only the welfare consequence (e.g. fear).

3.5.1.8. Rough handling of animals during removal from the containers

Definition: Manual removal of rabbits from containers in a way that causes pain and fear.

Two situations may exist:

- The containers are completely open, and animals do not have to pass through a door
- The containers have a narrow door and injury to the body can occur if rabbits are removed from the crate without due care.

Rough handling can cause pain and fear due to injuries that would appear as main carcass defects. These can be seen as post-mortem lesions, such as skin lesions, and bruising on body.

Process of slaughtering to which it applies: handling and removing of rabbits from crates or containers.

Hazard's preventive and corrective measures:

Rabbits should be removed from the containers individually by holding and lifting by the neck (scruff) by one hand, with or without support of the body with the other hand (European Union, 2017; Figure 12). The containers should be located as close as possible to the point of stunning. Once outside the container, their body should be supported with the other hand.

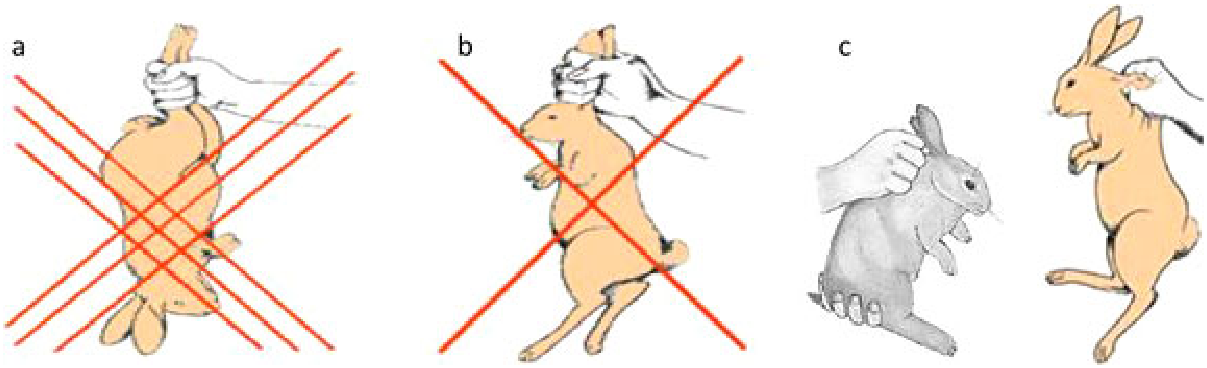


Figure 12: Poor practice of grasping rabbits by the hind legs (a) or by the ears (b), and good practice of grasping rabbits by the skin of the neck (c) (Source: Federation of French Poultry Industries)

Therefore, staff training and rotation, use of appropriate wide opening container are the most effective preventive measure. If the hazard still occurs, the line speed should be reduced. There is no corrective measure for this hazard.

3.5.2. List of hazards during Phase 2 – stunning

The hazards listed in this section apply to conscious rabbits before stunning or when ineffectively stunned or when they recover consciousness after being stunned.

3.5.2.1. Manual restraint

Definition: Catching and immobilisation of the rabbit with the hands of an operator.

Processes of slaughtering to which it applies: restraint for mechanical stunning methods, head-only electrical stunning and bleeding during slaughter without stunning.

Hazard's preventive and corrective measures:

Poor restraint can lead to misapplication of the stunning method.

Rabbits should be manually restrained firmly enough to facilitate the stunning, but without excessive pressure that would cause pain and fear. There is no preventive and corrective measure to this hazard, the only thing that an operator can do is perform it in the appropriate way which have been described in Sections 3.2.1 and 3.2.3. The welfare consequences pain and fear can be mitigated.

3.5.2.2. Inversion

Definition: Inversion is a restraining method used during percussive blow that involves holding the rabbit in an upside-down position. It can be done manually or by inserting each leg into a shackle or inverting the rabbit into a cone during slaughter without stunning.

Processes of slaughtering to which it applies: inversion of conscious animals for percussive blow and slaughter without stunning.

Hazard's preventive and corrective measures:

No preventive measure exists, except avoid shackling conscious animals. Once it is done, no corrective measures to the hazard do exist.

3.5.2.3. Shackling

Definition: involves hanging rabbits upside-down by inserting both legs into metal shackles.

Processes of slaughtering to which it applies: restraint after ineffective head-only electrical and mechanical stunning and monitoring of consciousness and bleeding during slaughter without stunning.

Hazards' preventive and corrective measures:

Monitoring of unconsciousness before shackling the rabbits. During slaughter without stunning, the inversion in a cone can replace the shackling.

3.5.2.4. Inappropriate shackling

Definition: Within the shackling procedure, inappropriate shackling of conscious rabbits can occur after ineffective electrical or mechanical stunning, slaughter without stunning, and when the shackles are too narrow or too wide or when rabbits are hung by one leg.

Additionally, it may happen that conscious rabbits are shackled when having injuries (e.g. with diseases or abnormalities of leg joints or bones and those with leg/dislocated joints or bone fractures); this situation exacerbates the welfare consequences occurring when shackling conscious rabbits.

Processes of slaughtering to which it applies: restraint after ineffective head-only electrical and mechanical stunning and inappropriate monitoring of consciousness and bleeding during slaughter without stunning.

Hazard's preventive and corrective measures:

Ensure that the rabbits are unconscious before shackling and the size and the design of the shackle are appropriate to the rabbits' size.

3.5.2.5. Poor electrical contact

Definition: The electric contact is not sufficient to facilitate flow of current to immediately stun the rabbits. This can result from: a) an incorrect placement of the electrodes that do not span the brain, b) an intermittent contact, c) the use of dirty/worn electrode(s).

In the case of intermittent contact, the electrical contact is interrupted, and hence, the desired flow of current through the brain is not achieved.

Dirt (e.g. originating from the rabbits' fur or carbonised debris) may accumulate on the electrodes leading to increased resistance to the current flow. The electrodes corrode over time due to repeated use, poor maintenance and lack of replacement leading to increased resistance of the current flow and localised heat generation. The good position of electrodes is very important and when Nodari et al. (2009) examined 1,020 crossbreed rabbits to evaluate their welfare during electrical stunning and slaughter in a commercial abattoir in Italy, they showed that electrodes were incorrectly applied to 10.8% of the rabbits.

Processes of slaughtering to which it applies: head-only electrical stunning

Hazard's preventive and corrective measures: see corresponding outcome table

The animal should be presented correctly and the equipment shall include electrodes for different sizes of animals' head in order that contact is ensured and current flows through the brain. Cleaning and maintenance of the electrodes has to be provided regularly.

3.5.2.6. Too short exposure time

Definition: The exposure time to electric current or to the gas concentration is too short to induce unconsciousness or resulting in recovery of consciousness.

Anil et al. (1998 and) Anil et al. (2000) reported that a minimum of 100 volts delivered using a 50 Hz sine wave alternating current for one-second resulted in an average current of 140 mA and is sufficient to induce unconsciousness and prevent recovery of consciousness, provided the stun-to-stick interval is less than 10 s.

For CAS stunning, a high concentration of CO_2 of more than 80% is adviced to induce effective stunning that will last long enough to ensure that animals will not recover before death occurs due to bleeding (Dalmau et al., 2016). The minimal exposure time used in the study of Dalmau et al. (2016) was 120 s'.

Processes of slaughtering to which it applies: head-only electrical stunning and CAS stunning
Hazards' preventive and corrective measures: see corresponding outcome table

3.5.2.7. Inappropriate electrical parameters

Definition: The electrical parameters (i.e. voltage, current, frequency, waveforms) fail to achieve epileptiform activity in the brain. It is caused for example by: too low voltage to generate sufficient current to achieve an effective stun, frequency too high to cause immediate unconsciousness, high electrical resistance of the rabbits in the system that prevents the current flow through the brain of the rabbits to cause immediate unconsciousness.
Processes of slaughtering to which it applies: head-only electrical stunning.
Hazard's preventive and corrective measures:
To prevent the use of inappropriate electrical parameters, the responsible person of the slaughterhouse should use the parameters appropriate to the frequency and waveforms of the current. The main parameter that needs to be considered is the minimum current delivered to the rabbits, which would depend upon the output voltage from the equipment (Ref.). The minimum current required to achieving effective stunning of rabbits is reported in Section 3.2.1. However, to ensure the voltage is sufficient to deliver minimum current, the responsible person of the slaughterhouse as a best practice, should evaluate the effectiveness of the electrical parameters monitoring signs of unconsciousness. In this evaluation process, the factors that could contribute to high electrical resistance in the pathway (e.g. density of the fur and of bones, the design and construction of the electrodes) should be identified and ways of minimising or eliminating them should be explored (e.g. wetting of the heads, selecting materials and design that offers least electrical resistance). Another way of overcoming the problem of high resistance is using a constant current stunner. Implementation of such an equipment would greatly benefit rabbit welfare at slaughter.

In rabbits, 50 Hz is the most commonly frequency used. Research has shown that a minimum of 100 volts delivered using a 50 Hz sine wave alternating current for one-second resulted in an average current of 140 mA and is sufficient to induce unconsciousness and prevent recovery of consciousness, provided the stun-to-stick interval is less than 10 s (Anil et al., 1998, 2000).

Voltage should be sufficient to overcome resistance in the pathway created by different tissues.

In another study, Nodari et al. (2009) evaluated electrical stunning of 1,020 crossbreed rabbits stunned with the system (TS003, Gozlin, Italy) incorporating a device capable of measuring impedance and giving a constant voltage of 117 V (peak to peak) and minimum 1.1 A for 1.31 $\pm$ 0.29 s (mean $\pm$ standard deviation). The time interval between stunning and sticking, measured on a sample of 50 rabbits, was 5.55 $\pm$ 0.88 s. Of these 50 rabbits, three were not stunned and were still conscious at sticking and 18 rabbits recovered during bleeding. In these rabbits, corneal reflex was present in all, three showed vocalisation and one showed head movement. Corneal reflex seemed to be the best indicator of recovery of consciousness in rabbits.

3.5.2.8. Incorrect shooting position

Definition: when the captive bolt is positioned wrongly, unconsciousness of the rabbits might be not achieved. The captive bolt should be placed at the intersection of lines drawn from the lateral canthus of each eye to the opposite ear, perpendicular to the skull bones.

Shooting of rabbits with a non-penetrating captive bolt on the head, i.e. frontal–parietal bones, induces brain concussion and immediate loss of consciousness. Proper restraint of the animal and presentation of its head are vital to achieving this. However, skin covering the rabbit's head can be loose in some breeds and, owing to this, and bolt may skid or slide leading to failure.
Process of slaughtering to which it applies: captive bolt stunning (PCB or NPCB)
Hazard's preventive and corrective measures: see corresponding outcome table

3.5.2.9. Incorrect bolt parameters

Definition: The bolt parameters fail to provoke an effective stun and render rabbits unconscious. It is caused for example by: low air line pressure, low cartridge power, low bolt velocity, shallow penetration and faulty equipment (too narrow bolt diameter).

It is also essential that the equipment is maintained and used according to the manufacturers' instructions. Stunning of rabbits with a NPCB induces reversible loss of consciousness (simple stunning), and therefore, the onus of preventing recovery after stunning relies on the prompt and accurate exsanguination. The earliest sign of recovery of consciousness in effectively stunned rabbit is recovery of spontaneous rhythmic breathing. Walsh et al. (2017) reported, 'A pattern predictive of a return to sensibility was convulsions suddenly stopping versus slowly fading out. No convulsions occurred when rabbits were sensible'. In this sense, tonic/clonic seizures either did not occur or ended abruptly in poorly stunned animals. Minimum bolt diameter of 6 mm has been recommended (European Commission, 2018).

Process of slaughtering to which it applies: captive bolt stunning (penetrative or non-penetrative)

3.5.2.10. Incorrect application of blow to the head

Definition: When the rabbits are hit in the wrong place, or with a force not sufficient to cause brain concussion. For rabbits, blow not delivered to the occipital region of the skull, just behind the ears.

One published study by Walsh et al. (2017) indicated that the probability of failure was highest when adult rabbits were stunned with manual percussive blow to the head (in comparison with non-penetrative captive bolt), with a 43% chance of incorrect application and unsuccessful stun. In addition, the results showed that ineffective stunning occurred in all age groups tested as presented in the table below. Poor restraint (manual suspension by hind legs) was suggested to be the causal factor.

Table 8: Captive bolt features (airline pressure) for various rabbit age groups (Walsh, Percival and Turner, 2017)

Age group	Number of animals used	Body weight kg (mean ± SE)	Successfully stunned (%)
0–5 weeks; pre-weaned	23	0.1 ± 0.03	87%
6–12 weeks; growers	21	1.6 ± 0.10	81%
> 12 weeks; adults	14	3.6 ± 0.30	57%

Potential hazards associated with percussive blow to the head are listed below. Poor restraint and operator fatigue are considered to be the major factors contributing to low success rate with this method. The accuracy of the blow and force delivered to the skull would vary according to the operators' fitness, skill levels and attitude (European Commission, 2017).

Processes of slaughtering to which it applies: percussive blow

Hazard's preventive and corrective measures: Appropriate tool and sufficient force. Operator rotation to avoid fatigue.

3.5.2.11. Too low gas concentration

The gas concentration is too low to render all rabbits unconscious within the exposure time or to prevent recovery of consciousness during bleeding.

Low CO_2 concentrations will prolong the induction of unconsciousness, leading to prolonged respiratory distress.

Process of slaughtering to which it applies: gas stunning methods.

Measures to prevent and correct the hazard: It is important to adequately monitor the gas concentration to maintain the required concentration breathed by the animals and keep injecting gas until the required levels are reached. The gas is vaporised before injection and its temperature monitored [see also relevant outcome table (Table 23)].

3.5.2.12. Exposure to too high CO2 concentration

Definition: Conscious rabbits are exposed to high CO2 concentrations. This can occur by direct or progressive exposure of conscious rabbits to a gas mixture containing more than 40% CO2. In case of carbon dioxide in two phases, this could also occur due to a combination of too low CO2 concentration and too short exposure time in the first phase leading to animals arriving conscious in the second phase in which CO2 is above 40%.

Process of slaughtering to which it applies: Gas stunning methods.

Hazard's preventive and corrective measures: It has been shown that rabbits find CO2 in concentrations higher than 70% causes painful stimulation of the nasal mucosa and aversive reactions (Llonch et al., 2012; Dalmau et al., 2016). Although lacking from scientific evidence, like in poultry and pigs, CO2 concentration higher than 40% might be also aversive for rabbits. Exposure of conscious rabbits to a concentration of CO2 higher than the aversive CO2 concentration should therefore be avoided.

Prevention of this hazard relies on proper monitoring of gas concentration and its maintenance below aversive concentrations during the induction of unconsciousness. If the concentration is aversive, a corrective measure is to inject air to reduce the concentration.

3.5.3. List of hazards during Phase 3

In the case of bleeding following stunning, the hazards apply to conscious rabbits (due to recovery of consciousness or ineffective stunning).

The hazards that may lead to recovery of consciousness in rabbits are: 'prolonged stun-to-neck-cut interval', and 'incomplete sectioning of carotids'.

The hazards that may lead to persistence of consciousness are those causing ineffective stunning (e.g. 'inappropriate electrical parameters', see hazards during Phase 2, Section 3.6.2).

When rabbits are conscious (e.g. all rabbits subjected to bleeding during slaughter without stunning; some rabbits ineffectively stunned or recovering consciousness following stunning), they will experience the negative welfare consequences (i.e. pain) due to the bleeding process.

The following hazards, from 3.5.3.2 to 3.5.3.7, apply to all conscious animals and hazards 3.5.3.1 will apply only to animal bled after stunning because it leads to recovery of consciousness.

All rabbits bled during slaughter without stunning will be submitted to the hazards described below, whereas only a proportion of rabbits bled following stunning application will be submitted to them, since it concerns only failure of the process due to the following circumstances:

- when rabbits are ineffectively stunned or when rabbits recover consciousness and
- when the state of consciousness is not properly monitored at key stages and
- when the back-up stunning systems are not implemented.

When rabbits are conscious, they will experience the negative welfare consequences (i.e. pain) due to the bleeding process (e.g. neck cutting or dressing of animals conscious or alive).

Signs of consciousness in the case of bleeding following stunning are: corneal or palpebral reflex, righting attempts, breathing, tonic/clonic seizure.

3.5.3.1. Prolonged stun-to neck-cut interval

Definition: the interval between end of simple stunning and neck cutting is too long to sustain unconsciousness until death occurs due to bleeding.

This is a hazard leading to recovery of consciousness. This will occur in plants with a long interval between the point of stunning and the neck cutting.

Process of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits)

Hazard's preventive and corrective measures: see Table 26.

Research has shown that the time to return of spontaneous breathing in head-only electrically stunned rabbit was 22 s (Anil et al., 2000) and an EU-wide survey of best practices in rabbit slaughterhouses indicated that maximum stun-to-stick interval is 10 s, exceptionally 20 s in one slaughterhouse (European Commission, 2017). The design and layout of slaughter facilities should be modified to keep the stun-to-stick interval to less than 10 s. Staff should be trained to perform prompt and accurate neck cutting.

If poor bleeding is suspected or observed after the cut, repeat cut should be performed immediately, and animals should be re-stunned prior to repeat cut if they show signs of consciousness.

3.5.3.2. Incomplete sectioning of carotids

Definition: failure to cut both carotid arteries to prevent oxygenated blood supply to the brain.

In bleeding following stunning, this hazard can lead to recovering of consciousness.

During slaughter without stunning, the time to onset of unconsciousness and death will be prolonged.

Processes of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits), bleeding during slaughter without stunning (100% of rabbits).

Hazard's preventive and corrective measures: see Tables 26 and 27.

Preventive measures include training of staff to sharpen knifes frequently and to perform prompt and accurate severance of both carotid arteries. If incomplete sectioning is suspected or recognised after the first cut staff should perform a second cut immediately to prevent recovery of consciousness in animals.

3.5.3.3. Neck cutting

Definition: incision of skin, soft tissues, nerves and blood vessels in the neck of rabbits.

In bleeding following stunning, it applies only to animals remaining conscious or recovering consciousness.

In bleeding during slaughter without stunning, this hazard is a part of the method; therefore, it applies to all animals.

Processes of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits), bleeding during slaughter without stunning (100% of rabbits).

Hazard's preventive and corrective measures: see Tables 26 and 27.

The only preventive measure is to monitor consciousness immediately after stunning and at the time of neck cutting to ensure animals are unconscious. Staff should be trained to sharpen knife routinely and perform prompt and accurate neck cutting. The corrective measure is to re-stun the animal prior to neck cutting.

There is no corrective or preventive measure in the case of slaughter without stunning.

3.5.3.4. Repeated cuts

Definition: multiple application of neck cuts.

When rabbits are slaughtered without stunning, repeated cuts correspond to sawing movement with a knife. When rabbits are bled after stunning repeated cuts might happen when both carotids are not severed during the first intervention.

Processes of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits), bleeding during slaughter without stunning (100% of rabbits).

Hazard's preventive and corrective measures: see Tables 26 and 27.

The only preventive measure is to monitor consciousness immediately after stunning and at the time of neck cutting to ensure animals are unconscious. Staff should be trained to sharpen knife routinely and perform prompt and accurate neck cutting. The corrective measure is to re-stun the animal prior to neck cutting.

There is no corrective or preventive measure in the case of slaughter without stunning.

3.5.3.5. Stimulation of wounds

Definition: physical stimulation of the tissues and nerve ending in the cut surface. It mainly occurs due to the restraint or manipulation.

Processes of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits), bleeding during slaughter without stunning (100% of rabbits).

Hazard's preventive and corrective measures: see Tables 26 and 27.

The only preventive measure is to monitor consciousness immediately after stunning and at the time of neck cutting to ensure animals are unconscious. The corrective measure is to re-stun the animal prior to neck cutting.

There is no corrective or preventive measure in the case of slaughter without stunning.

3.5.3.6. Bleeding to death

Definition: inducing gradual loss of consciousness and death due to bleeding.

Processes of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits), bleeding during slaughter without stunning (100% of rabbits).

Hazard's preventive and corrective measures: see Tables 26 and 27.

The only preventive measure is to monitor consciousness immediately after stunning and at the time of neck cutting to ensure animals are unconscious. The corrective measure is to re-stun the animal prior to neck cutting.

There is no corrective or preventive measure in the case of slaughter without stunning.

3.5.3.7. Dressing of rabbits while still alive

Definition: rabbits with signs of life undergoing carcass processing.

Rabbits can remain alive when processing begins under two scenarios:

i) the time to onset of death will be prolonged if both carotid arteries are not cut
ii) short bleed out time – if the bleed out time is not sufficient to cause death before processing

Processes of slaughtering to which it applies: bleeding following stunning (on a proportion of rabbits), bleeding during slaughter without stunning (100% of rabbits).

Hazard's preventive and corrective measures: see Tables 26 and 27.

One way of avoiding live rabbit being processed is to ensure proper monitoring of consciousness and death at slaughter during key stages, as recommended for other species (EFSA AHAW Panel, 2013c–f).

3.5.3.8. Drops, curves and inclination of shackle line

Definition: The moving shackle line may include sharp curves, inclinations, drops and bunchy transitions, causing irregular movements that can increase the force the shackles exert on the legs of the animals. The irregular movements and increased force on the legs can lead to painful compression and a fear response.

Process of slaughtering to which it applies: Restraint for slaughter without stunning.

Hazard's preventive and corrective measures: see Table 27.

No prevention/correction measures have been identified other than redesign of the shackle line to avoid this hazard.

3.5.4. Considerations on the hazards and their distribution

The exposure to some hazards might persist along processes and phases until the unconsciousness of the rabbits (e.g. food and water deprivation) (see Tables 18–21). Other hazards might be present only during one phase, but the welfare consequence might persist during the following phases (e.g. pain due to rough handling). Furthermore, some hazards in Phase 2 are specific to the stunning method applied (see Tables 22–25).

Table 9 here below shows an overview of hazards during different processes in Phase 1.

Furthermore, interaction among hazards may exacerbate some animal welfare consequences. An interaction exists when several factors are contributing to the same welfare consequence. For example, it is well described that rough handling increases the risk of leg fractures and haematomas of legs. In case of slaughter without stunning or insufficient stunned rabbits are subjected to compression of their legs during shackling. If they have been injured due to rough handling, this can lead to additional suffering. In this case, the consequence of exposure to the two hazards will be greater than the sum of the consequences of the two hazards present in isolation (EFSA AHAW Panel, 2012a).

Table 9: Overview of hazards during different processes in Phase 1 – pre-stunning

Hazard	Arrival	Unloading of containers	Lairage	Handling and removing of rabbits from crates or containers
Too high effective temperature	x		x	
Too low effective temperature	x		x	
Insufficient space allowance	x		x	
Food deprivation too long	x		x	
Water deprivation too long	x		x	
Unexpected loud noise			x	x
Rough handling of containers		x		
Rough handling of the rabbits during removal from the containers				x
Total no. of hazards	5	1	6	2

It should be noted that some of the hazards identified for these steps are indeed combinations of hazards, for example: 'too high effective temperature' resulted from the WG assessment as a combination of 'temperature' with 'air speed' and 'humidity'.

Additionally, some of the hazards identified through the literature search have been removed from the final list reported in the outcome tables after WG discussion; this is the case e.g. of 'prolonged time of waiting at arrival or lairage' that the experts recognised to have a role in making the effect of some hazards worse, as a cumulative effect (e.g. the effect of 'too high effective temperature' or 'food/water deprivation too long' at arrival and at lairage is exacerbated when in combination with 'prolonged time of waiting'), but not to be a hazard *per se*. It is indeed clear that the duration of a phase/step affects the effects of the hazards. The origin of a prolonged lairage duration could be in the planning of transport arrival (catching and journey time not well predicted), the planning of the slaughter schedule (too many groups to slaughter at the same time) or in a technical issue (failure in the slaughter process inducing delay). In this sense, 'unload immediately' and 'reduce waiting time to unloading and lairage' are important actions to reduce or mitigate the welfare consequences caused by a hazard but they are not measures aimed at cancelling the hazard.

Of course, also hazards recognised as such, like 'insufficient space allowance' at arrival, can increase or temperate the effects of other hazards. When bad combination happens (sometimes combined with weak animals/bad transportation conditions), then rabbits welfare troubles can lead to death which is reflected in 'death on arrival' (DOA, see Section 3.1.4).

Table 10 here below shows an overview of hazards during different processes in Phase 2.

Table 10: Overview of hazards for different methods during Phase 2 – stunning

	Stunning methods			
Hazard	**Head-only electrical**	**CAS**	**Captive Bolt**	**Percussive blow**
Manual restraint	x		x	x
Inversion	x			x
Shackling	x		x	
Poor electrical contact	x			
Inappropriate shackling	x		x	
Too short exposure time	x	x		
Inappropriate electrical parameters	x			
Exposure of rabbits to too high CO_2 concentration		x		
Too low concentration of gas		x		
Incorrect shooting position			x	
Incorrect bolt parameters			x	
Incorrect application of blow to the head				x
Total no. of hazards	**6**	**3**	**3**	**3**

3.5.5. Assessment of uncertainty

3.5.5.1. Uncertainty analysis about the outcome tables

Uncertainty related to the occurrence of false-negative and false-positive hazards was assessed (see methodology described in Section 2.2.4).

Regarding the possible occurrence of false-negative hazards, the experts were 90–95% certain that they identified all welfare hazards considered in this assessment according to the three criteria described in the Interpretation of ToRs. However, when considering a global perspective, the experts were 95–99% certain that at least one welfare hazard is missing. This is due to the lack of documented evidence on all possible variations in the processes and methods being practiced on a worldwide scale (see Interpretation of ToRs on the criteria for selection of stunning/killing methods to be included).

Regarding the possible inclusion of false-positive hazards, the experts were 95–99% certain that all listed hazards exist during slaughter of rabbits.

3.5.5.2. Uncertainty analysis about indicator sensitivity, specificity and ease of use

The results of the analysis of uncertainty related to the indicator sensitivity, specificity and ease of use is provided quantitatively in Section 3.6.2.2, where the uncertainty intervals are provided in Tables 14, 15 and 16.

3.5.6. Origin categories and specifications

On the basis of experts' knowledge, the origins of the hazards have been identified and categorised in terms of facilities/equipment or staff, as required by the mandate.

The category of 'staff' includes all the personnel involved in unloading, movement, restraint, stunning and slaughter of rabbits, including food business operator and those with responsibility for welfare of rabbits.

'Facilities' mean permanent features, fixtures and fittings including layout, design and construction of the slaughterhouse and various associated structures/features intended for receiving, lairaging, stunning and slaughter of rabbits.

'Equipment' includes machinery or tools used on live rabbits for handling, restraining, stunning and slaughter. For example, containers used for transporting rabbits, forklift used for unloading, ventilation system in lairage, stunning devices and associated calibrating and monitoring systems or knives used for slaughtering rabbits.

An overview of the origin category(ies) pertaining to each of the hazards identified in the sections above is reported in the following tables (Tables 11–13).

When discussing the origin categories, it was considered necessary to explain them further by detailing what actions from the staff or features from equipment and facilities can cause the hazard. Therefore, for each 'origin category' (staff, facilities/equipment), relevant 'origin specifications' have been identified by expert opinion. Relevant origin specifications have been reported in the outcome tables, developed by processes of the slaughter (see Section 3.10). In addition, in some cases, specific evidence has been retrieved in the literature supporting the 'origin specification' identification and reported in the current section.

'This is the case for example of 'too high effective temperature', whose specific origin can be a combination of high temperature and humidity in the environment where animals were placed, combined with too high stocking density (Petracci et al., 2010) and no active mechanical ventilation.

Owing to the complexity of slaughter some hazards, especially those in the pre-stunning phase, involve all the three origin categories, and some others identified in stunning and bleeding phases involve one or two categories (i.e. staff and equipment).

Poorly designed, constructed and maintained slaughterhouse facilities would result in recurring chronic problems and require investment to prevent hazards; some hazards in this category may have corrective measures and others may not.

'Staff' contribute to most of the hazards. Almost all of the hazards originating from staff could be attributed to lack of appropriate skill sets needed to perform tasks or fatigue and therefore have preventive measures, which includes recruitment of people with right attitude and aptitude, staff training and staff rotation.

'Equipment' is an important category contributing to the second highest number of hazards in all the phases, especially during stunning.

Inevitably, preventive or corrective measures appropriate for a hazard would vary according to the origin category. The proportion of rabbit subjected to hazards could also vary according to the origin category.

Table 11: Overview of the origin categories relevant to the hazards identified for Phase 1 – pre-stunning

Hazards	Staff	Facility	Equipment
Too high effective temperature	x	x	x
Too low effective temperature	x	x	x
Insufficient space allowance	x		
Food deprivation too long	x		
Water deprivation too long	x		
Unexpected loud noise	x	x	x
Rough handling of containers	x	x	
Rough handling of the rabbits during removal from the containers	x	x	x

Table 12: Overview of the origin categories relevant to the hazards identified for Phase 2 – stunning (including restraint)

Hazards	Staff	Facility	Equipment
Manual restraint	x		
Inversion			x
Shackling			x
Inappropriate shackling	x		x

Hazards	Staff	Facility	Equipment
Poor electrical contact	x		x
Too short exposure time	x		
Inappropriate electrical parameters	x		x
Incorrect shooting position	x		
Incorrect bolt parameters	x		x
Incorrect application of blow to the head	x		
Too low gas concentration	x		x
Exposure to too high CO2 concentration	x		x

Table 13: Overview of the origin categories relevant to the hazards described in Phase 3, in the case of bleeding following stunning, and in Phases 2 and 3 in the case of bleeding during slaughter without stunning (including restraint)

Hazards	Staff	Facility	Equipment
Manual restraint*	x		
Inversion*			x
Shackling*			x
Inappropriate shackling*	x		x
Prolonged stun-to-neck-cut interval	x		x
Neck cutting	x		
Incomplete sectioning of carotids	x		x**
Repeated cuts in conscious rabbits	x		x**
Stimulation of wound	x		
Bleeding to death	x		x**
Dressing of rabbits still alive	x		
Drops, curves and inclination of the shackle line		x	x

*: Hazards that have been described in Section 3.5.2 and apply to bleeding during slaughter without stunning (because in the case of bleeding following stunning they have been included in the relevant stunning method).

**: Staff and also equipment only in the case of bleeding following stunning, when the hazard/s applies only to a proportion of rabbits (the ineffectively stunned and the ones recovering consciousness after stunning).

3.6. Response to ToR-2: Criteria to assess performance on animal welfare

The mandate requests to define animal-based indicators that can be used to assess welfare performance.

3.6.1. Welfare consequences

There are several potential (negative) welfare consequences that an animal can experience if slaughtering is not carried out correctly. However, due to the complexity of slaughtering and the limited access to animals in some of the phases (e.g. animals in containers at arrival and lairage, or in the chambers during gas stunning, etc.), not all the welfare consequences can be assessed at the slaughterhouses.

Ten welfare consequences occurring to rabbits during the processes of slaughtering have been identified by the experts. Some of the welfare consequences are specific to the pre-stunning phase (i.e. heat stress, cold stress, prolonged thirst and restriction of movement), others are specific to the stunning phase (consciousness) and others can apply in all phases (pain, fear, distress).

For the welfare consequences in Phase 1 (pre-stunning), several indicators to assess the welfare of rabbits have been reported (EFSA, 2005; de Jong et al., 2011).

In the case of Phases 2 (stunning) and 3 (bleeding), namely for the assessment of the efficacy of the stunning and bleeding processes, qualitative and measurable criteria ought to be used too. For other species, e.g. poultry, EFSA developed a Scientific Opinion on 'the monitoring procedures at slaughter for poultry' (EFSA AHAW Panel, 2013d) where indicators for consciousness have been selected based on their specificity and sensitivity, and have been included in 'toolboxes' specific for the identified scenarios. For rabbits, a similar exercise was done, and the results are reported in chapters 3.6.2 (selection of indicators) and 3.6.3 (flow charts).

3.6.1.1. Description of the welfare consequences, associated indicators and mitigation measures

The welfare consequences that have been identified as the ones that rabbits can experience at the time of slaughter are described below in this section. Relevant indicators are also listed, and they will be described in detail in the following Section 3.6.1.

The measures that can be used to mitigate the welfare consequences are also reported here.

Thermal stress (heat or cold stress)

Definition: The animal is unable to maintain constant body temperature by behavioural adaptation alone.

The comfort zone temperature for rabbits is around 21°C. At either higher or lower temperatures, the animal has to expend energy to maintain its body temperature (Marai et al., 2002).

The comfort limits for rabbits (Marai et al., 2002) are defined as: temperature–humidity index (THI) < 27.8°C, absence of heat stress; 27.8–28.9°C, moderate heat stress; 28.9–30°C, severe heat stress; THI > 30°C, very severe heat stress.

Rabbits are very sensitive to high temperature since they are fur animals and they have limited ability in eliminating excess body heat. Rabbits cannot easily lose heat through evaporation, e.g. by sweating or panting. Moreover, the latter is very inefficient when the environmental temperature is in excess of 30°C (Fayez et al., 1994). Since rabbits do not sweat, at temperatures above 25–30°C they stretch out to lose as much heat as possible by radiation and convection, raise their ear temperature, stretch the ear pinnae and spread them far from the body to expose the surface to the surroundings in order to increase heat dissipation. The heat stress induces physiological changes e.g. depression in feed intake, disturbances in water, protein, energy and mineral metabolism balances, enzymatic reactions, hormonal secretions and blood metabolites (cited in: Marai and Rashwan, 2004; Johnson, 1980; Wittroff et al., 1988; Habeeb et al., 1992; Kasa and Thwaites, 1992). Thermal stress is related to higher blood cortisol, lactate and glucose, creatine kinase and lactate dehydrogenase enzymes, and greater osmolarity (De La Fuente et al., 2004).

When the temperature rises above 30°C, the feed intake of rabbits decreases, which can decrease weight gain in growing rabbits and milk production of does as well as milk intake of kits. Some diseases (e.g. dermatomycoses) are directly related with some environmental factors as high temperature and humidity, or temperature changes (EFSA, 2005).

According to Lebas et al. (1986), rabbits can no longer regulate their internal temperature above 35°C and heat prostration sets in, while at 40°C, considerable panting and salivation occurred. The average lethal body temperature was considered to be 42.8°C.

Rabbits are mostly affected by heat stress after weaning age, especially in Mediterranean countries or in hot summer periods. In buildings, the ambient temperature and other atmospheric conditions are controlled to a certain extent, whereas this is not regulated in outdoor systems.

Exposure to high ambient temperature induces rabbits to try to balance the excessive heat load by using different means to dissipate, as much as possible, their latent heat. Optimal climatic conditions for rabbits would be: air temperature 13–20°C (average 15°C) and relative humidity 55–65% (average 60%) (Marai and Rashwan, 2004; Voslarova et al., 2018).

Cold stress has a less significant effect on rabbit welfare compared to heat stress. Luzi et al. (1992) observed lower liver and muscle glycogen concentration as evidence of increased muscle activity during winter transport. Others confirm that cold stress is marked by only superficial fatigue and muscular damage (De la et al., 2007).

Indicators

Heat stress: The rabbit shows increased respiration rate, higher temperature of ears and keeping ears spread open and away from the body.

Cold stress: Kits (first week of life) that are unable to return to the nest, become hypothermic and immobile.

Outside the range of optimal ambient temperature, behavioural changes can be observed in rabbits. During the first 10–12 postnatal days, the kits have only a limited capacity for independent thermoregulation, and they huddle together covering themselves with the nest material by crawling under it (Hudson and Distel, 1982; Bautista et al., 2008). In case of 30 min at 20.0°C, the rectal temperature of kits drops from 37.7°C to 32.7°C (Cardasis and Sinclair, 1972).

When the ambient temperature increases above 30°C, rabbits show a significantly higher respiration rate, more than 32–60 respirations per minute in does which is probably age dependent (Harcourt-Brown, 2002). They stretch out to lose heat by radiation and convection, stretch ear pinnae and spread them far from the body to expose the surface to the surroundings, while the ear temperature increases (Marai and Rashwan, 2004). They decrease their activity levels (Marai and Rashwan, 2004). According to Peeters (1989), they have extremely red ears.

Rafel et al. (2012) observed the behaviour of breeding rabbits under continuous 18°C ambient temperature (control), or under 20°C in general, which was increased to 28°C from 9:00 h to 16:00 h. They found that a control group spent 15–25% of time in prostration (lying in a stretched out position, ventrally, laterally or dorsally) while rabbits under heat stress spent more time prostrated (45–54%), with a peak during the warmest hours. Their results also suggested that, when the temperature changes according to circadian cycles, animals are able to predict the increment of temperature, and they increase some important activities (e.g. grooming) in the colder period, which will be not performed during the warmer hours.

de Jong et al. (2011) suggest that although meat rabbits may show huddling behaviour in response to cold stress, this is not a good indicator as they generally prefer lying together and huddle whilst resting at normal temperatures (16–18°C). However, in their overview tables, they still refer to huddling as a feasible measure. They also do that in their subsequent publication (Rommers et al., 2015) and it seems the measure is still valid.

When the ambient temperature is below 10°C, rabbits curl up to minimise their body's surface area, the ear temperature is lower, the ear pinnae are folded to remove the internal surface from contact with air and rabbits drop the ears to bring them closer to the body (Marai and Rashwan, 2004).

In summary, animal-based measures for heat stress are

1) panting associated with a high respiration rate
2) reddening of the ears
3) salivation
4) and, in extreme conditions death.

The potential indicators for cold stress are

1) huddling (piling up, overcrowding)
2) dropping the ears
3) vasoconstriction,
4) and, in extreme conditions death

Mitigation measures:

Measures to mitigate heat stress are increase space allowance; immediate unloading following the arrival; the provision of adequate ventilation to the truck at arrival place; assuring appropriate ventilation and the protection from adverse weather conditions.

Mitigating actions are to provide adequate ventilation, unload the truck immediately and bring the rabbits to a thermal neutral zone.

Measures to prevent cold stress are to provide curtains and other protection and close the ventilation prior to departure; to avoid coldest hours of the day for transport; to unload immediately following the arrival; and to provide adequate shelter to the truck at arrival place.

Prolonged hunger

Description:

Prolonged hunger occurs when the animal has been unable to get enough food to meet its maintenance requirements for energy, proteins or specific nutrients. Fasting affects the feeling of hunger, and therefore animal welfare. Prolonged hunger will lead to loss of body weight due to starvation. Rabbits are fasted prior to transport and slaughter, and there is a risk of feed being removed too early, transport being delayed or prolonged or too long waiting time in lairage, resulting in prolonged hunger for the rabbits.

Food deprivation affects meat quality (ultimate muscle pH; Jolley, 1990). It also affects carcass yield and live weight losses. Emptying of the guts is mainly causing weight loss over the first 4–6 h (Lambertini et al., 2006). If food deprivation persists beyond 6 h, there will be a reduction in water content and nutrients from body tissues with a corresponding effect on carcass yield (Trocino et al., 2003). According to Cavani and Petracci (2004), rabbits lose 3–6% of body weight during the first 12 h of fasting. This increases to about 8–12% at 36–48 h. Cachexia (loss of weight, muscle atrophy, fatigue, weakness and significant loss of appetite) is an indicator for prolonged hunger at the farm. It is a slow process that does not occur during transport and slaughter.

Indicators: The potential indicators for prolonged hunger in rabbits are for example the presence of bile, urates or orange casts (sloughed intestinal lining) on the floor of the containers (Manitoba, CIFA, https://www.gov.mb.ca/agriculture/livestock/production/commercial-rabbit/feed-withdrawal-a-practical-look-at-its-effect-on-intestine-emptying-contamination-and-yield.html) and weight loss.

Although weight loss is indicative of a metabolic crisis, there is no practical animal-based measure in the slaughterhouse to estimate the magnitude of the issue. According to de Jong et al. (2011), the percentage of emaciated rabbits at the farm is assessed by the farmer before they are transported to the slaughter plant, or at the slaughter plant. This figure may be a good indicator of hunger. Body condition scoring is slightly more sophisticated and de Jong et al., 2011 report two scoring systems under development. Bonanno et al. (2008) measure the fatness by palpating loin and rump regions and scored body condition on a scale from 0 to 2. Rosell and de la Fuente (2008) estimated body condition by weighing and palpating different regions. They interpret these in relation to the size of the doe on a lineal scale of 1–9. At the time of reporting, both systems need further development and validation before they could be used in an assessment protocol (de Jong et al., 2011).

Behavioural responses to 24-h food deprivation include an alternation of short periods of search behaviour (4–10 min) and longer periods of relative rest (20–70 min) as indication of spontaneous fluctuations in the food motivation level (Kromin et al., 2016).

The search behaviour is characterised by a pronounced exploratory activity (restlessness, multiple head turns in different directions, sniffing, rearing vertically). During periods of relative rest, freezing behaviour turning into drowsiness is the main behavioural state. However, in the absence of apparent behavioural activity including sniffing, food motivation is still detectable, as *alai nasi* muscles of hungry rabbits constantly generate bursts of action potentials synchronous with breathing. At the same time, upper oesophageal sphincter muscles exhibited regular aperiodic low-amplitude impulse activity of tonic type (Kromin et al., 2016).

Therefore, possible animal-based parameters are:

1) body condition score (does and meat rabbits, on-farm);
2) percentage of emaciated rabbits at the slaughter plant (meat rabbits).
3) Movement of nostrils

Mitigating measures

To prevent prolonged hunger, attention should be paid to the planning of feed withdrawal on-farm according to duration of transportation and waiting time prior to slaughter; and the scheduling and prioritisation of slaughter of animals;

To mitigate hunger, food and water should be provided.

Prolonged thirst

Description: An animal is thirsty when it has been unable to get enough water to satisfy its needs, resulting in dehydration.

Thirst is an intrinsic response to dehydration, triggered by two physiological factors – volumetric and/or osmotic stimuli. Thirst occurs either when there is a fall in blood volume or when the tonicity of the interstitial fluid increases. An example where both occur together is when animals do not have access to water during hot weather with the worst animal welfare consequences.

If drinking water is not provided and the only feed available is dry with a moisture content of less than 14%, dry matter intake drops to nil within 24 h. With no water at all, and depending on temperature and humidity, an adult rabbit can survive from 4 to 8 days without any irreversible damage, though its weight may drop 20–30% in less than a week (Lebas et al., 1986).

Indicators:

de Jong et al. (2011) suggest that there are no indicators available which will measure prolonged thirst in a practical way. A potential indicator for dehydration is a dry skin, but this is practically impossible to examine on live rabbit at slaughter, and not necessarily easy to evaluate post-mortem either. Another theoretically valid indicator is 'death on arrival' (DOA), but this is rather unspecific and more commonly caused by hyperthermia than by actual dehydration.

de Jong et al. (2011) suggest that the only measures available are resource-based measures, to avoid thirst. They refer to Verga et al. (2009): for individually housed does, one nipple per doe is sufficient, and for meat rabbits and group housed does, one nipple per 10 rabbits should be a minimum.

Mitigating measures:

Rabbits should have access to water till catching and loading in containers.

Restriction of movement

Description: Meat rabbits show simultaneous resting (de Jong et al., 2011). Buijs et al. (2011) suggests that stocking density as well as group size may have an effect on resting behaviour, by either disturbing resting or increasing time spent resting in small cages. Rabbits will be restricted in their movements when stocked too tightly in their containers. It may result in an inability to sit together at the same time or to change their body position. de Jong et al. (2011), referring to expert discussions on the on-farm situation of rabbit resting behaviour, question whether it is necessary that all animals can use the resting area at the same time.

It is important to note that the need for space is associated with ambient temperature, as animals will need more space to dissipate heat when temperatures increase.

Indicators: There are no clear indicators for restriction of movement. If rabbits are kept in close proximity of each other, this does not necessarily mean that they are overstocked and suffer from stress. In fact, it is suggested that rabbits voluntary huddle (de Jong et al., 2011).

Indirect measures that can be used are taken from crate dimensions in relation to the number of rabbits: the space allowance. *Mitigation measures*: as it is not feasible to provide more space to rabbits in the containers that arrive at the abattoir, the mitigation measures should be to speed up the process, by removing animals from containers as soon as possible, and slaughter them as soon as they arrive to the slaughterhouse.

Fear

Description: Fear has been defined as 'a feeling which occurs when there is perceived to be actual danger or a high risk of danger'; it can produce changes in behaviour, physiology and in the brain (Broom and Fraser, 2015). Excessive fear may cause chronic stress, which affects animal welfare and health (Forkman et al., 2007). Moreover, excessive fear may cause serious trauma and injuries during handling when animals struggle and are difficult to be handled.

As prey animals and because of their recent domestication, rabbits are widely recognised as tame or fearful towards man, predators and any stimulus. However, recent studies have demonstrated that changes in brain architecture of domestic rabbits are consistent with altered fear processing and, thus, compared with their wild ancestors, domestic rabbits are less fearful and have an attenuated flight response (Brusini et al., 2018).

Fear can be elicited by different occasional stimuli or even by defective management and housing conditions, which can affect animal response and welfare to a different extent depending on the frequency of occurrence, duration and severity of the threat. In the slaughter house situation, rabbits might experience fear during unloading of containers, lairage, handling and removing of animals from containers and during phases 2 and 3 (stunning and bleeding).

Indicators

Rabbits react to fear or threat by 'fight-or-flight' response, but also assume motionless postures until tonic immobility (also defined as immobilisation catonia or death feigning) (Giannico et al., 2014). Under different conditions (farmed, lab or pet rabbits), when exposed to different possible threats (noises, presence of man or unknown operators, introduction of new animals), rabbits have been observed running away into a hiding place or into a corner of the cage with their head, or freezing, or attacking with teeth and claws (Mullan and Main, 2006; Crowell-Davis, 2007; Verga et al., 2007).

Measurements of fear levels in rabbits have been based on changes in behaviour or occurrence of some behaviours, reactivity tests as well as physiological indicators (EFSA, 2005; Verga et al., 2007;

Verwer et al., 2009; Buijs and Tuyttens, 2015; Trocino et al., 2018a,b). Indeed, as for the other species, the interpretation and evaluation of the results require special care and an approach as much as possible comprehensive, since some behavioural and physiological indicators are associated with more than one feeling (Broom and Fraser, 2015). Moreover, no measurable (numerical) thresholds have been given to identify and certainly determine not acceptable fear levels with regard to animal welfare and health.

Signs of fear are generally not feasible to be assessed while animals are housed in containers. Possible indicators in the slaughter house situation are:

1) Flight (escape) or startling behaviour
2) Vocalisations
3) Tonic immobility

Mitigation measures:

Mitigating measures are to identify and eliminate the source of fear, where possible.

Pain

Description: This opinion uses the definition of pain from the International Association for the Study of Pain (IASP): 'Pain can be defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage'. Most of the processes of slaughtering are painful for conscious animals.

Indicators:

Since pain is a subjective feeling, its intensity, or even presence, can be very difficult to diagnose, especially in prey species which have been subject to evolutionary pressure to minimise external signs of this state. There are few validated assessment tools for pain assessment in conventional rabbits, but there has been extensive research into pain assessment in laboratory rabbits and this knowledge can be applied in the commercial context. Laboratory research has validated changes in behaviour, facial expressions and body temperature for pain assessment (Farnworth et al., 2011; Leach et al., 2011; Keating et al., 2012). Behavioural changes include reduced feeding and drinking, tight huddle posture (sitting with their back arched and fore and hind limbs drawn in tightly), locomotory changes including shuffle (walking at a very slow pace) and partial hop movements (forward extension of forelimbs as if to hop, without movement of hind limbs) (Farnworth et al., 2011). General grooming is also reduced, although sites of injury may receive increased grooming (Farnworth et al., 2011). EFSA (2005) noted that although rabbits are normally silent animals, they may squeal loudly if in severe pain or distress; they may also grind the teeth in cases of more chronic pain. More recently, the use of facial expression as an indicator of pain has been validated in rabbits (Keating et al., 2012). The Rabbit Grimace Scale assesses five different facial action units (orbital tightening, cheek flattening, nose shape, whisker position and ear position) to create an overall score that increases when rabbits experience pain.

From all of the above indicators, vocalisations seem to be the only practical one in the slaughterhouse. In addition, withdrawal responses or escape attempts from painful stimuli during the slaughter process are also indicative of pain. In addition, pain can be indirectly assessed by scoring the injuries. Feasible indicators are physical damages to the muscles and skin (e.g. scratches and open wounds, bruises). Traumatic injuries during postmortem inspection have been considered (Grilli et al., 2015) to be an indicator for bad transport, loading/unloading and handling causing negative welfare consequences, without possibility to distinguish the phase(s) where the injuries appeared.

Therefore, possible indicators in the slaughter situation are:

1) Vocalisations
2) Injuries to muscles and skin
3) Withdrawal reactions and escape attempts

Mitigation measures:

There are no mitigating measures during the stunning process, other than to proceed as effectively as possible.

Distress

Description: This is the state of an animal that has been unable to adapt to stressors and that manifests as abnormal physiological or behavioural responses (Chapter 7.8.1 OIE, 2019). Distress implies an external and usually temporary cause of great physical or mental strain and stress, such as extreme anxiety or fear, inability to cope with environmental conditions, sadness, pain or the state of being in danger or urgent need.

At slaughter, rabbits are exposed to a number of distressing situations in a short period of time. However, distress is a welfare status difficult to describe, assess and quantify accurately. The bleeding phase has been identified as the one where mostly, when rabbits are not properly stunned/not unconscious, they are exposed to different hazards leading to a combination of welfare consequences including distress.

ABMs: no specific ABMs have been identified to assess distress. However, depending on the origin of physical or mental distress, ABMs for other welfare consequences such as pain or fear or thermal stress, can be applied.

Mitigation measures: Post-cut stunning will eliminate distress as well as other welfare consequences that the rabbits experience when bleeding while conscious.

Respiratory distress

Description: Mental or physiological suffering due to increased $CO2$ levels or to lack of $O2$ resulting in forced breathing, breathlessness or air hunger.

Respiratory distress can also be induced by the lack of oxygen or hypoxaemia during stunning by inert gas mixtures (Beausolei and Mellor, 2015); however, there is no direct experimental evidence available in the literature.

Indicators:

In CAS, gasping or intense breathing is a sign of respiratory distress and is seen as indicator for breathlessness. Gasping is mostly characterised by very deep breathing with an open mouth (EFSA, 2004), and it is induced by the increased $pCO2$ in the blood, which will stimulate the breathing centre in order to wash out $CO2$. Rabbits exposed to atmospheric air did not show respiratory distress (gasping nor headshacking). On the other hand, Llonch et al. (2012) reported a higher percentage of rabbits gasping when exposed to 90% $CO2$ than to 80% $N2$ and 20% $CO2$ (97 vs. 42%). The level and intensity of gasping depend on the $CO2$ concentration during the induction phase.

Mitigation measures: respiratory distress is inherent to the stunning method. Therefore, no mitigation measures can be implemented.

State of consciousness

Description

Consciousness is the ability of an animal to feel emotions, to be sensitive to external stimuli and able to control its voluntary mobility. Consciousness is a prerequisite for experiencing welfare consequences, and can be caused by ineffective stunning or when animals are recovering consciousness after stunning.

In fact, failure to induce proper stunning and therefore unconsciousness, or recovery of consciousness following stunning will lead to animals being conscious during further processing. As a result, there is a risk that the rabbits are neck cut and even dressed while conscious, or that regain consciousness during the bleeding process. As 'being alive' is a prerequisite of being conscious, indicators for death are also included. Analogous to earlier EFSA opinions published on other species (EFSA AHAW Panel, 2013c–f), the indicators for the state of consciousness (and death) in rabbits were analysed in this opinion, and selected to be included in a monitoring system for rabbit slaughter. The information about the indicators for the state of consciousness in rabbits is presented separately in the following chapter 3.7.2.

Mitigation measures: re-stun with a back-up stunning method, and implementation of pre- or post-cut stunning, in the case of slaughter without stunning.

State of death

Description

Animals that are not dead at the end of bleeding. In both slaughter with or without stunning, death should be ensured just before dressing. Death should be confirmed by ensuring the presence of signs of death.

3.6.2. Indicators for the state of consciousness and death to monitor rabbit slaughter

To respond to the EP mandate, indicators for assessing the state of consciousness and death were selected based on their sensitivity and specificity and ease of use and included in flow charts (see Sections 3.6.2 and 3.6.3) and in the outcome tables (see Section 3.10).

3.6.2.1. Description of the indicators

The following indicators are used to identify the state of consciousness and death. These were used in the flow charts (Section 3.6.3).

Indicators for the state of consciousness

Righting reflex: Head righting (attempt to raise head), head shaking after stunning. Conscious animals (ineffectively stunned rabbits and those recovering consciousness) may attempt to raise their heads during the three key stages of monitoring, which is referred to as righting reflex in this opinion, and animals showing this reflex will have to be re-stunned. Unconscious animals will not show the righting reflex.

Breathing: Effective electrical stunning will result in immediate onset of apnoea (absence of breathing). During CAS stunning breathing is affected but not suppressed immediately. After loss of consciousness, animals will show suppressed or non-rhythmic breathing. At the end of the stunning cycle breathing should be suppressed to the level of being absent, only some gasping may occur. Ineffectively stunned animals and those recovering consciousness will start to breathe in a pattern commonly referred to as rhythmic breathing, which may begin as regular gagging and involves respiratory cycle of inspiration and expiration. Rhythmic breathing can be recognised from the regular flank and/or mouth and nostrils movement. Recovery of breathing, if not visible through these movements, can be checked by holding a small mirror in front of the nostrils or mouth to look for the appearance of condensation due to expiration of moist air. In key stage 1, effectively stunned rabbits can be recognised from the absence of breathing (apnoea). In key stage 2 (just prior to neck cutting), unconscious rabbits will continue to manifest apnoea. In contrast, a rabbit recovering consciousness whilst hanging on the overhead shackle will attempt to breathe, which may begin as regular gagging before leading to resumption of breathing; such an animal will have to be re-stunned using a back-up method. An effectively stunned and stuck rabbit will remain unconscious until death occurs in key stage 3 and therefore is not expected to show any signs of breathing. On the other hand, a rabbit recovering consciousness whilst hanging on the overhead shackle and bleeding will attempt to breathe, and will have to be re-stunned using a back-up method.

Tonic–clonic seizures: Unconscious animals show tonic–clonic seizures. Tonic seizures can be recognised by an arched back and rigidly flexed legs under the body, and will last for several seconds. It is followed by clonic seizures lasting for seconds and manifested as leg kicking or paddling. Tonic seizure may end, and therefore not seen, if there was a long delay between the end of captive stunning and shackling. Conscious animals do not show tonic/clonic seizures.

Vocalisation: One or repeated, short and loud shrieking (screaming) at high frequencies. Vocalisation is expected only in conscious animals and can be used as an indicator in all key stages of monitoring. However, not all conscious animals will vocalise, and hence, the absence of vocalisation does not always mean that the animal is unconscious. Animals showing vocalisation must be re-stunned using a back-up method.

Corneal reflex: The corneal reflex is elicited by touching or tapping the cornea. Conscious animals will blink in response to the stimulus. Unconscious animals show the absence of the corneal reflex during any key stage. On the other hand, conscious animals are expected to show the presence of the corneal reflex at any key stage.

Palpebral reflex: The palpebral reflex is elicited by touching or tapping a finger on the inner/outer eye canthus or eyelashes. Correctly, stunned animals will not show a palpebral reflex. Ineffectively stunned animals and those recovering consciousness will blink in response to the stimulus at any key stage. Animals showing a positive palpebral reflex must be re-stunned using a back-up method.

Spontaneous blinking: Conscious animals may show spontaneous blinking, and therefore, this sign can be used to recognise ineffective stunning or recovery of consciousness after electrical stunning. However, not all the conscious animals may show spontaneous blinking. Spontaneous blinking can be used as an indicator at all key stages of monitoring.

Immediate collapse: Effective captive bold and electrical stunning will result in immediate loss of posture leading to collapse of the animal. Ineffectively stunned animals, on the other hand, will fail to collapse or will attempt to regain posture after collapse. Some ineffectively stunned animals (as may occur, for example, if shooting position is wrong) may lose posture as a result of the impact of the bolt and remain collapsed, but conscious.

Indicators for the state of death

Cessation of bleeding: Slaughter eventually leads to cessation of bleeding, with only minor dripping, from the neck cut wound, and therefore, the end of bleeding can be used as an indicator of death.

Muscle tone: Electrically stunned animals will show general loss of muscle tone after the termination of tonic–clonic seizures coinciding with the recovery of breathing and the corneal reflex if not previously stuck. Effective CAS stunned will show complete loss of muscle tone if exposed long enough to the gas concentration and convulsive movements have ceased. Loss of muscle tone can be recognised from the completely relaxed legs, floppy ears and relaxed jaws. Ineffectively stunned animals and those recovering consciousness will show a righting reflex and attempts to raise the head. Muscle tone can be used at all three key stages. On the other hand, ineffectively stunned animals and those recovering consciousness at all key stages will retain or recover certain levels of muscle tone, manifested as stiff (upright) ears and jaws, and righting reflex (e.g. severe kicking, head lifting, body arching). Animals showing any of these signs of muscle tone must be re-stunned using a back-up method.

Heartbeat: Onset of death leads to permanent absence of heart beat, which can be ascertained physically by using a stethoscope where possible.

Dilated pupils: Dilated pupils (mydriasis) are an indication of death.

3.6.2.2. Results on sensitivity, specificity and ease of use of the indicators

The results of the EKE are summarised in the following tables, in which uncertainty related to sensitivity, specificity and ease of use is included. For sensitivity and specificity, the uncertainty is expressed using a 90% interval, where a bigger uncertainty interval indicates a higher uncertainty. For 'ease of use', the uncertainty is expressed as a percentage of certainty (see methodology Section 2.2.4) where a higher percentage indicates a higher degree of certainty.

The tables also categorise the indicators according to the methodology explained in Section 2.2.3 into indicators that are suggested, additional or not to be included in the flow charts (see Section 3.6.3).

The following three tables present the results on indicators for electrical stunning, mechanical stunning and those to be used at the time of dressing.

Table 14: Based on the results of the elicitation workshop, the following values were obtained for sensitivity, specificity and ease of use of all indicators for monitoring consciousness during **electrical stunning**, for the three key stages. Indicators are divided by those suggested for use in the flow charts, those proposed as additional indicators or those not included in the flow charts

Sensitivity, specificity and ease of use of all indicators of the state of consciousness for electrical stunning				
Indicator	**Sensitivity (median and 90% uncertainty interval)**	**Specificity (median and 90% uncertainty interval)**	**Ease of use***	**Certainty about ease of use**
Key stage 1 (immediately after stunning)				
Suggested indicators				
Palpebral/corneal reflex	94% (77%–99%)	97% (89%–100%)	2.3 – moderate	22% – Medium certainty
Tonic–clonic seizures	93% (78%–99%)	96% (87%–99%)	1.1 – easy	70% – High certainty
Breathing	92% (70%–99%)	97% (88%–100%)	2.6 – difficult	34% – Medium certainty
Additional indicators				
Spontaneous blinking	69% (21%–97%)	99% (96%–100%)	1.5 – easy	33% – Medium certainty
Vocalisation	57% (9%–96%)	98% (91%–100%)	1.0 – easy	100% – High certainty
Indicators not included in the flow chart				
Righting reflex	77% (35%–98%)	98% (93%–100%)	1.7 – moderate	22% – Medium certainty
Immediate collapse	77% (32%–98%)	95% (80%–100%)	2.1 – moderate	17% – Low certainty

Sensitivity, specificity and ease of use of all indicators of the state of consciousness for electrical stunning				
Indicator	**Sensitivity (median and 90% uncertainty interval)**	**Specificity (median and 90% uncertainty interval)**	**Ease of use***	**Certainty about ease of use**
Key stage 2 (just prior to neck cutting)				
Suggested indicators				
Palpebral/corneal reflex	94% (77%–99%)	97% (89%–100%)	2.0 – moderate	23% – Medium certainty
Tonic–clonic seizures	93% (73%–99%)	95% (82%–100%)	1.8 – moderate	60% – High certainty
Breathing	92% (70%–99%)	97% (88%–100%)	2.6 – difficult	20% – Low certainty
Righting reflex	77% (35%–98%)	98% (93%–100%)	2.1 – moderate	17% – Low certainty
Additional indicators				
Spontaneous blinking	69% (21%–97%)	99% (96%–100%)	1.4 – easy	51% – High certainty
Vocalisation	57% (9%–96%)	98% (91%–100%)	1.1 – easy	69% – High certainty
Indicators not included in the flow chart				
Immediate collapse	77% (32%–98%)	95% (80%–100%)	3.0 – difficult	100% – High certainty
Key stage 3 (during bleeding)				
Suggested indicators				
Palpebral/corneal reflex	94% (77%–99%)	97% (89%–100%)	2.1 – moderate	30% – Medium certainty
Breathing	92% (70%–99%)	97% (88%–100%)	2.5 – difficult	19% – Low certainty
Tonic–clonic seizures	91% (66%–99%)	87% (56%–99%)	2.3 – moderate	22% – Medium certainty
Righting reflex	77% (35%–98%)	98% (93%–100%)	2.2 – moderate	13% – Low certainty
Additional indicators				
Spontaneous blinking	69% (21%–97%)	99% (96%–100%)	1.4 – easy	34% – Medium certainty
Vocalisation	57% (8.6%–96%)	98% (91%–100%)	1.1 – easy	67% – High certainty
Indicators not included in the flow chart				
Immediate collapse	77% (32%–98%)	95% (80%–100%)	3 – difficult	100% – High certainty

*: The distribution of answers for ease of use is reported in the appendix.
**: For details, see the appendix.

Table 15: Based on the results of the elicitation workshop, the following values were obtained for sensitivity, specificity and ease of use of all indicators for monitoring consciousness during **captive bolt stunning** for the three key stages. Indicators are divided by those suggested for use in the flow charts, those proposed as additional indicators or those not included in the flow charts

Sensitivity, specificity and ease of use of all indicators of the state of consciousness for captive bolt stunning				
Indicator	**Sensitivity (median and 90% uncertainty interval)**	**Specificity (median and 90% uncertainty interval)**	**Ease of use***	**Certainty about ease of use**
Key stage 1 (immediately after stunning)				
Suggested indicators				
Palpebral/corneal reflex	96% (85%–100%)	98% (91%–100%)	1.9 – Moderate	17% Low certainty
Breathing	92% (68%–99%)	97% (88%–100%)	2.6 – difficult	34% Medium certainty
Tonic–clonic seizures	85% (57%–98%)	93% (73%–99%)	1.0 – easy	100% High certainty

Sensitivity, specificity and ease of use of all indicators of the state of consciousness for captive bolt stunning				
Indicator	**Sensitivity (median and 90% uncertainty interval)**	**Specificity (median and 90% uncertainty interval)**	**Ease of use***	**Certainty about ease of use**
Additional indicators				
Vocalisation	71% (37%–93%)	98% (92%–100%)	1.0 – easy	100% High certainty
Spontaneous blinking	69% (21%–97%)	99% (96%–100%)	1.4 – easy	34% Medium certainty
Indicators not included in the flow chart				
Righting reflex	77% (35%–98%)	98% (93%–100%)	1.7 – moderate	22% Medium certainty
Immediate collapse	77% (32%–98%)	97% (86%–100%)	1.9 – moderate	17% Low certainty
Key stage 2 (just prior to neck cutting)				
Suggested indicators				
Palpebral/corneal reflex	96% (85%–100%)	98% (91%–100%)	1.9 – moderate	22% Medium certainty
Breathing	92% (68%–99%)	97% (88%–100%)	2.6 – difficult	20% Low certainty
Tonic–clonic seizures	89% (62%–99%)	86%(58%–98%)	1.9 – moderate	30% Medium certainty
Additional indicators				
Vocalisation	71% (37%–93%)	98% (92%–100%)	1.2 – easy	60% High certainty
Spontaneous blinking	69% (21%–97%)	99% (96%–100%)	1.1 – easy	65% High certainty
Indicators not included in the flow chart				
Immediate collapse	77% (32%–98%)	97% (86%–100%)	3 – difficult	100% High certainty
Righting reflex	77% (35%–98%)	98% (93%–100%)	2.1 – moderate	17% Low certainty
Key stage 3 (during bleeding)				
Suggested indicators				
Palpebral/corneal reflex	96% (85%–100%)	98% (91%–100%)	2.1 – moderate	22% Medium certainty
Breathing	92% (68%–99%)	97% (88%–100%)	2.5 – difficult	19% Low certainty
Righting reflex	77% (35%–98%)	98% (93%–100%)	2.1 – moderate	13% Low certainty
Additional indicators				
Vocalisation	71% (37%–93%)	98% (92%–100%)	1.2 – easy	60% High certainty
Spontaneous blinking	69% (21%–97%)	99% (96%–100%)	1.4 – easy	27% Medium certainty
Indicators not included in the flow chart				
Immediate collapse	77% (32%–98%)	97% (86%–100%)	3 – difficult	100% High certainty
Tonic–clonic seizures	73% (57%–99%)	88% (32%–96%)	2.1 – moderate	17% Low certainty

Table 16: Based on the results of the elicitation workshop, the following values were obtained for sensitivity, specificity and ease of use of all indicators for monitoring death during bleeding following slaughter with or without stunning

Specificity, sensitivity and ease of use of indicators of death to be used prior to dressing following slaughter with or without stunning				
Indicator	**Specificity* (median and 90% uncertainty interval)**	**Sensitivity (median and 90% uncertainty interval)**	**Ease of use**	**Certainty about ease of use**
Suggested indicators				
Breathing	98% (93%–100%)	90% (63%–99%)	2.3 – moderate	36% Medium certainty
Bleeding	97% (91%–100%)	96% (83%–100%)	1.1 – easy	70% High certainty
Muscle tone	94% (79%–100%)	91% (66%–99%)	1.0 – easy	100% High certainty
Additional indicators				
Heart beat	99% (94%–100%)	92% (71%–99%)	2.7 – difficult	36% Medium certainty
Dilated pupils	98% (91%–100%)	85% (50%–99%)	2.4 – difficult	34% Medium certainty

*: An indicator is considered 100% specific if it identifies all alive animals as alive.

Based on these values, graphs were built to facilitate the selection of the most appropriate indicators according to the procedure described in Section 2.2.4.2. An example of these graphs is shown here below (Figure 13). The other graphs can be found in Appendix C.

For the indicator 'tonic–clonic seizure', the experts agreed that this parameter will change noticeably during the slaughter process. Therefore, it was decided to assess the sensitivity and specificity for each key stage separately. For the other indicators, the specificity and sensitivity were judged only once for all key stages. The ease of use was assessed for each key stage separately as the animals are in different postures or locations, which may affect access.

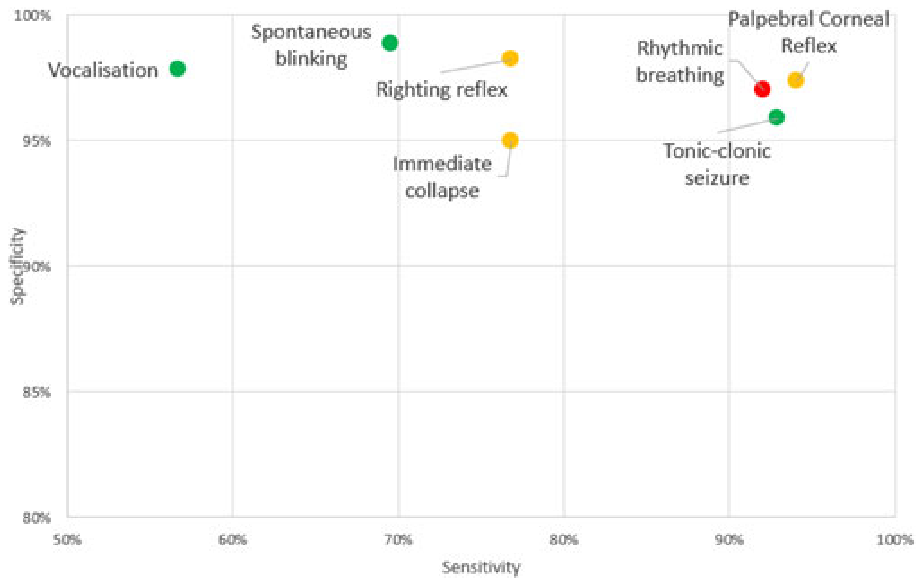


Figure 13: Example of a graph that was used to select the most relevant parameters. This is the EKE result for Key stage 2 (just prior to neck cutting) following electric stunning. Easiness is expressed by different colours (green = easy, orange = moderate, red = difficult)

3.6.3. Flow charts of indicators to monitor the efficacy of stunning and killing methods

The resulting flow charts are presented in the figures below. They show 'toolboxes' with indicators that can be used to assess the state of consciousness (following the stunning methods), or death of the animal. A dashed line separates three indicators that are recommended to be used in practice (above the dashed line) from additional indicators which can also be used (below the dashed line).

Of the recommended indicators above the dashed line, a minimum of two indicators relevant to each key stage should be employed for an effective monitoring of the process. The indicators below the dashed line have lower sensitivity or specificity and they should not be relied upon solely. In particular, those indicator outcomes which rely on the animal spontaneously manifesting certain behaviours (e.g. spontaneous blinking, vocalisations) should be used with caution. These outcomes are presented in grey as a reminder of the limited predictive value of the indicator. Nevertheless, the outcome of consciousness suggests that the animal is conscious and is a 'warning signal' requiring an intervention.

For each of the toolboxes, the outcome of the indicator assessment can either be that the next step in the process can be taken (green boxes) or that an appropriate intervention should be applied before proceeding (red boxes). The first two figures present the toolboxes related to slaughter with stunning. There are three, representing the three key stages. For the first key stage (just after stunning), if the animal shows any of the signs of consciousness (red box), then appropriate intervention should be applied. If no indicator suggests that the animal is conscious, i.e. all performed checks resulted in outcomes of unconsciousness (green box), then the animal can be shackled. At the time of neck cutting a further check of consciousness should be performed using the indicators of Toolbox 2. If the animal shows any of the outcomes of consciousness (red box), then appropriate intervention should be applied. If no indicator suggests consciousness, i.e. all performed checks resulted in outcomes of unconsciousness (green box), then it can be proceeded to the third key stage, during bleeding.

During this key stage, the animals should be monitored for signs of regaining consciousness, prior to death. Before dressing can take place the final flow chart (for indicators of death) should be applied. This flow chart is relevant for all slaughtered animals: so animals with and without prior stunning. It supports taking the decision whether animals can be dressed, or whether the operator should wait longer as the animal is not dead yet. Rabbits need to be confirmed dead before they can be dressed.

3.6.3.1. Flow chart for Electrical Stunning

In toolbox 1, the key indicators for monitoring effective stunning immediately following application are tonic/clonic seizures, corneal or palpebral reflex and breathing.

In toolbox 2, the key indicators for monitoring effective stunning at the time of neck cutting are tonic/clonic seizures, corneal or palpebral reflex, breathing and also the righting reflex. If the rabbit is conscious, righting reflex will be observed at this key stage when it is released from manual restraint and hung on the shackle. It is worth mentioning that righting reflex may not be manifested in key stage 1 when the animal is under manual restraint.

In toolbox 3, the key indicators for monitoring effective stunning during bleeding are corneal or palpebral reflex, breathing and righting reflex. Even though the ideal stun to stick interval is less than 10 s, it is thought that tonic/clonic seizures may end before, and therefore, this indicator is not included in this key stage.

It is to be noted that 'breathing' is considered 'difficult' to apply, however, it is a sensitive indicator and therefore it was included in the suggested indicators. In addition, for all three key stages, less sensitive indicators that were judged as easy to use were spontaneous blinking and vocalisation. Spontaneous blinking and vocalisation are judged throughout the slaughtering process as easy to use but not very sensitive. These indicators are the first to appear when regaining consciousness and easy to recognise. However, the absence of these does not necessarily ensure unconsciousness.

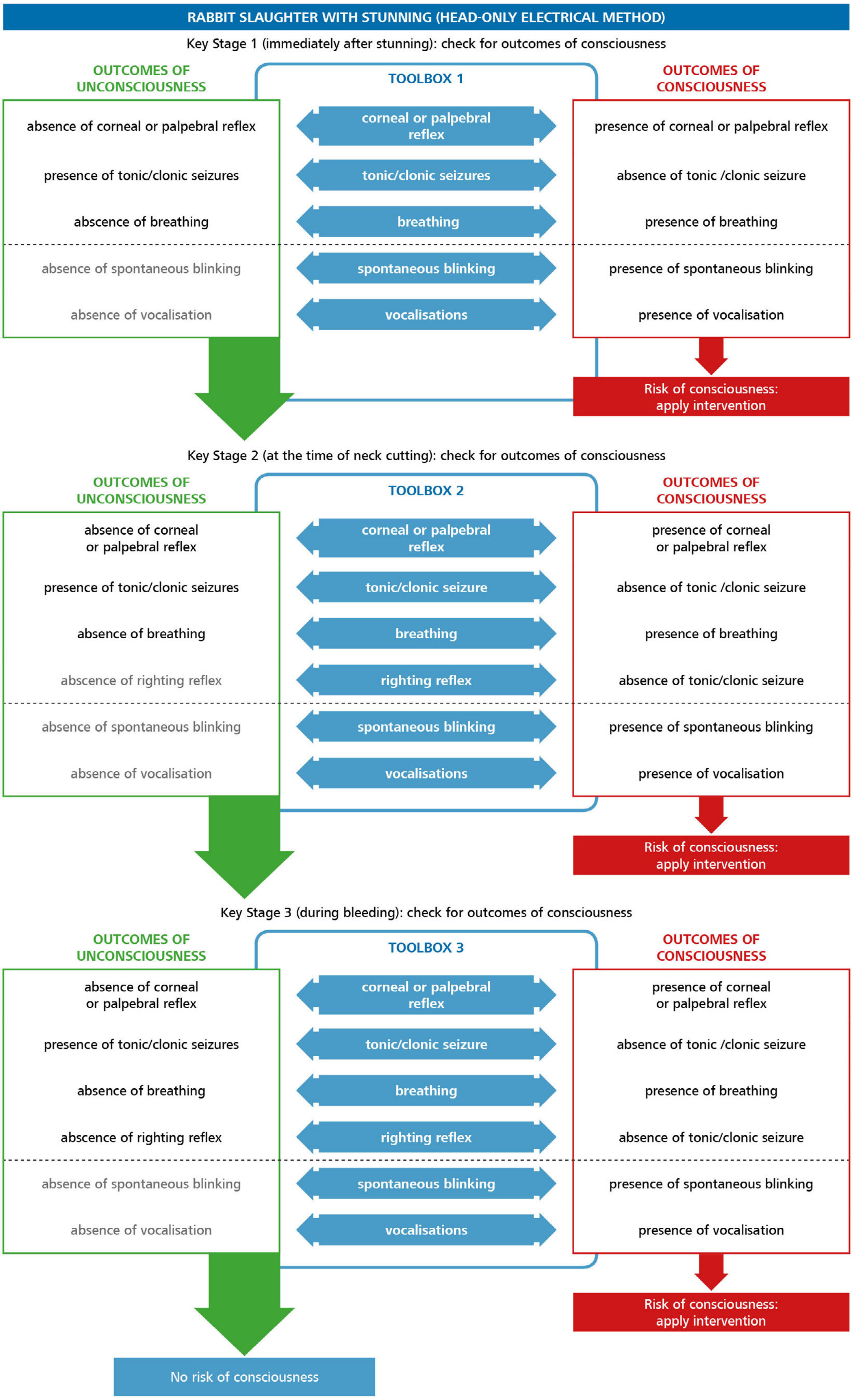


Figure 14: Flow chart describing the decision taking process during the slaughter of rabbits when applying electrical stunning

3.6.3.2. Flow chart for captive bolt

In toolbox 1, the key indicators for monitoring effective stunning immediately following application are corneal or palpebral reflex, breathing, immediate collapse and tonic/clonic seizures. Tonic/clonic seizures and immediate collapse can easily be observed whilst the animal is restrained on the surface. However, the righting reflex may not be observed reliably because the animal is manually restrained in an upright position.

In toolbox 2, the key indicators for monitoring effective stunning at the time of neck cutting are corneal or palpebral reflex, breathing and righting reflex.

In toolbox 3, the key indicators for monitoring effective stunning during bleeding are corneal or palpebral reflex, breathing and righting reflex.

For both toolboxes 2 and 3, immediate collapse cannot be observed because the animal is hung on the shackle line for the purpose of neck cutting. Instead, righting reflex is included because the animal is free to manifest it. As in electric stunning, vocalisation and spontaneous blinking were suggested as additional indicators for all three key stages because they are easy to use but rather not sensitive.

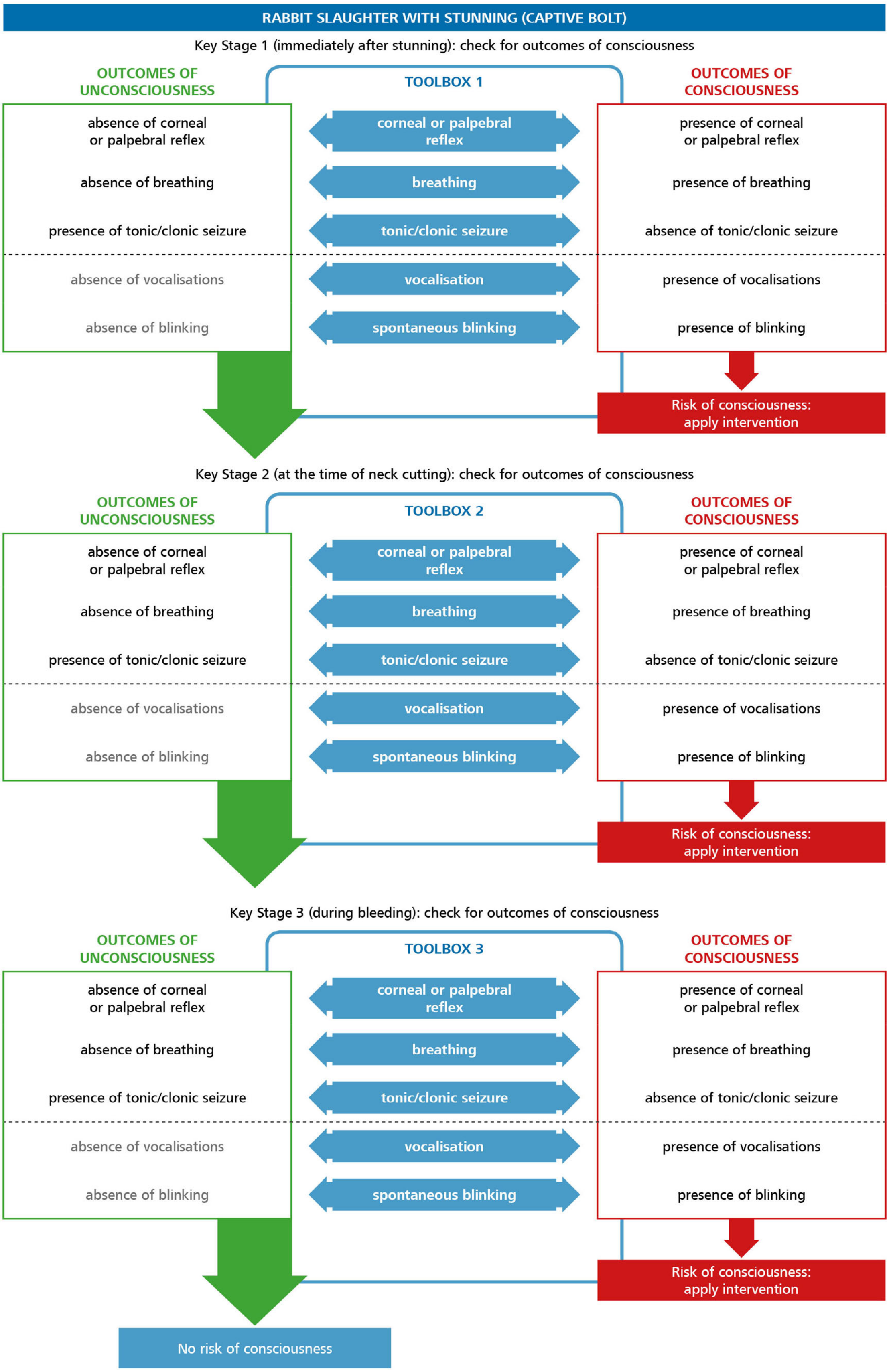


Figure 15: Flow chart describing the decision taking process during the slaughter of rabbits when applying captive bolt stunning

3.6.3.3. Flow chart prior to dressing following slaughter with and without stunning

The following figure presents the toolbox to be used before dressing following slaughter with or without stunning, and recommends indicators of death that can be used to decide if dressing can start.

The indicators of death were generally judged as less sensitive than the indicators of consciousness. Cessation of bleeding is the indicator that has the highest sensitivity and specificity and is easy to use, whereas the other four indicators are either less sensitive/specific or difficult to recognise. All five indicators of death should be taking into account when assessing death.

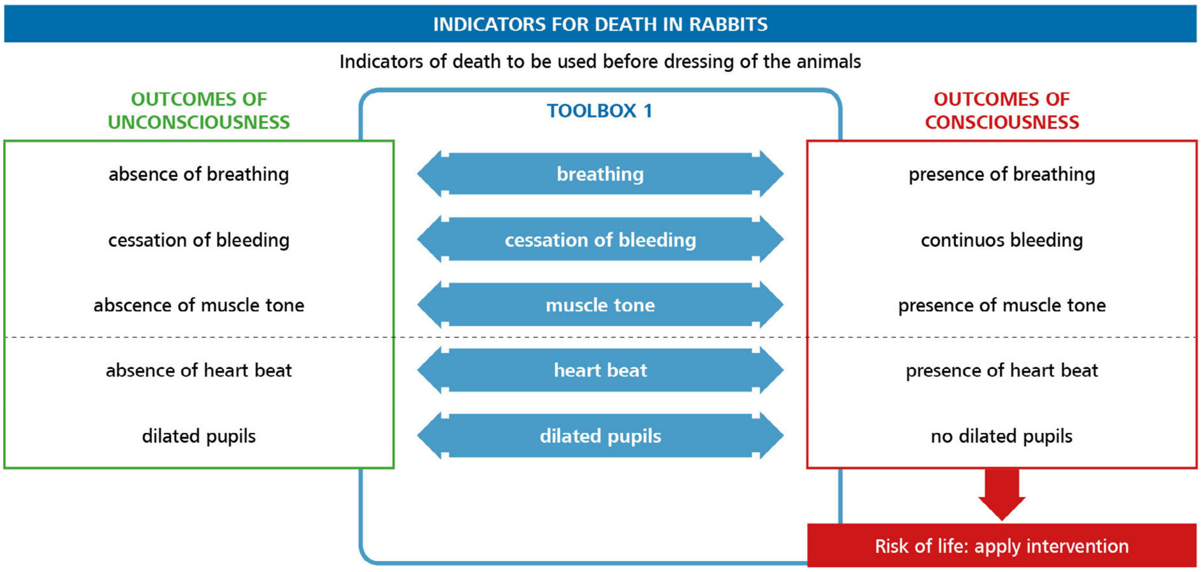


Figure 16: Flow chart for confirmation of death (slaughter with or without stunning)

3.6.4. Indicators and their definitions

As mentioned previously, indicators are used to assess the welfare consequences; indeed, indicators are the responses of an animal to a specific input and can be taken directly from the animal or indirectly by using animal records (e.g. number of dead animals on arrival at the slaughterhouse) (EFSA AHAW Panel, 2012a).

Some indicators may not be feasible to be used under certain circumstances, for example, rabbits in the middle of the container may not be visible for the assessment. In such situations, even if welfare consequences are not measurable by using indicators at the slaughterhouse, it does not imply that they do not exist: if the hazard is present, the related welfare consequences should be assumed to be present too.

Table 17: List of indicators referred to in this opinion, their definitions and the welfare consequences they are related to. The references for the definitions are given in brackets. If a reference is not presented, the definition is based on experts' opinion

Indicators	Definition with References	Relevant welfare consequences
Attempt to regain posture	Head righting (attempt to raise head), head shaking or after stunning. Also: righting reflex	Consciousness
Bunching	Clustering together on one part of the available floor space (also: 'huddling'). de Jong et al. (2011)	Fear
Cessation of bleeding	Profuse bleeding from the neck cut wound following neck cutting reduces after a few seconds to minor dripping	Consciousness
Consciousness	The state of awareness of a normal animal when it can perceive stimuli from its external environment and respond in the normal behaviour of an awake individual. (EFSA, 2006)	Consciousness

Indicators	Definition with References	Relevant welfare consequences
Corneal reflex	Blinking response to touching the eyeball (EFSA, 2006)	Consciousness
Death	A physiological state of an animal, where respiration and blood circulation have ceased as the respiratory and circulatory centres in the medulla oblongata are irreversibly inactive (EFSA, 2006)	Heat stress, cold stress
Deep breathing	Deep breathing often with open mouth (EFSA, 2006)	Respiratory distress
Dilated pupils	Wide open pupils ('mydriasis') (EFSA, 2006)	Consciousness
Escape attempts (or startling behaviour)	Attempts to move or run away from the situation	Fear, pain
Gagging or gasping	Rudimentary respiratory activity occurring through mouth (oral breathing) (EFSA, 2006)	Consciousness
Head shaking	Rapid shaking of the head, most times accompanied by stretching and/or withdrawal movements of the head	Pain, fear and/or respiratory distress
Heart beat	The beating of the heart	Life/death
Huddling	Sitting close together in tight groups or clumps often with open space in between de Jong et al. 2011. Also: 'bunching'	Cold stress
Immediate collapse	The immediate loss of posture leading to collapse of the animal	Consciousness
Injuries	Tissue damage (bruises, scratches, broken bones, dislocations)	Pain
Muscle tone	Loss of muscle tone can be recognised from the completely relaxed legs, floppy ears and relaxed jaws with protruding tongue	Consciousness
Palpebral reflex	Closing the eyelid following touching or tapping a finger on the inner/outer eye canthus or eyelashes	Consciousness
Panting	Breathing with short, quick breaths and an open mouth de Jong et al. (2011)	Heat stress
Piling up	Rabbits crowding against and on top of each other	Restriction of movement
Dropping of the ears	Rabbits drop the ears to bring them closer to the body (Marai and Rashwan, 2004)	Cold stress
Reddening of the ears	The ears of the rabbit turn from pink to red (Peeters, 1989)	Heat stress
Righting reflex	Attempts to regain normal posture	Consciousness
Salivation	An abnormally abundant flow of saliva	Heat stress
Spontaneous blinking	Natural blinking, unprovoked or as menace reflex: the reflex blinking that occurs in response to the rapid approach of an object. AVMA Guidelines	Consciousness
Startling behaviour	Attempts to move or run away from the situation. Also 'Escape attempts'	Fear
Tonic–clonic seizures	Tonic seizures can be recognised by an arched back and rigidly flexed legs under the body, and will last for several seconds. It is followed by clonic seizures lasting for seconds and manifested as leg kicking or paddling (EFSA, 2006)	Consciousness
Tonic immobility	A motionless posture resulting from acute fear (also defined as immobilisation catonia or death feigning) (Giannico et al., 2014)	Fear, pain
Vocalisation	One or repeated, short and loud shrieking (screaming) at high frequencies	Fear, pain
Withdrawal reaction	Fast avoiding movement of the stimulated part of the body (i.e. neck, head or leg; Walsh et al., 2017)	Pain

3.7. Response to ToR 3: identification of preventive and corrective measures

The hazards that potentially appear during slaughtering can be prevented or corrected by putting in place structural or managerial actions. Preventive and corrective measures refer to the actions that can be implemented to avoid or stop the hazard. In case there is no possible correction for certain hazards, then measures to mitigate welfare consequences linked with the hazards have been described in the text of the opinion (Section 3.6.1).

In general, according to the mandate, preventive and corrective measures can be grouped into two broad categories:

- 'Structural' measures mean infrastructure or facilities required to minimise or eliminate occurrence of hazards or minimise suffering in rabbits.
- 'Management' measures mean decisions to be made or resources to be put in place by personnel with responsibility or legal obligation for animal welfare.

On the basis of experts' knowledge and when available, considering the literature, for each of the hazards identified relevant preventive and corrective measures have been listed in the outcome tables, developed by phases of the slaughter process (for details, see Section 3.10, Tables 18–27).

In addition, specific preventive and corrective measures have been developed in association with the relevant hazards' description in Section 3.6.

Preventive measures that apply to several hazards (e.g. staff training) are describe below in this section, whereas there are no general corrective measures but, when available, they are specific for each hazard (and then described in Section 3.5).

In the case of corrective measures, only those that are considered feasible to implement in a slaughterhouse have been reported. It has to be noted that, due to the fact that the slaughtering of rabbits is a continuous process, the corrective measures feasible to be put in place would also become preventive measures for the following rabbits in the slaughter line.

3.7.1. List of preventive measures

3.7.1.1. Staff training

Description: Training of staff to acquire knowledge and skills required to perform their allocated task efficiently. It includes the realisation that animals are sentient beings that can suffer from pain and fear, and therefore, should be treated correctly in order to avoid negative welfare consequences. Staff training was identified as a preventive measure for hazards in all the processes assessed (see Tables 18–27), confirming that even in a well-designed and equipped slaughter plant, training of staff is a key point to ensure the protection of animals (European Commission, 2017).

3.7.1.2. Staff rotation

Description: Staff rotation is a management policy in which employees are moved between two or more tasks to avoid boredom and fatigue. Boredom is an important factor that can lead to hazards during slaughter of rabbits. Staff carrying out tasks associated with live animals should be rotated to other duties at regular intervals to safeguard rabbit welfare.

Staff rotation has been identified as an important preventive measure during routine handling, electrical stunning, mechanical stunning and slaughter without stunning.

3.7.1.3. Scheduling and prioritising rabbits for slaughter

Description: It consists in planning and coordination of arrival of live rabbits, unloading, lairage and slaughter, including communication with farms, live animal catching teams, hauliers (European Commission, 2017). This would apply to all the methods of slaughter/killing of rabbits.

Effective coordination should minimise waiting time upon arrival of the animals and keep lairage duration to the minimum (European Commission, 2017). Scheduling of slaughter should also include contingency plans to prioritise slaughter of animals on the basis that holding them in lairage for any longer would lead to further suffering.

3.7.1.4. Appropriate design and maintenance of facilities and equipment

Description: Design, construction and routine maintenance of slaughterhouse facilities and equipment is important to ensuring good welfare (European Commission, 2017). This applies to all the equipment used in the slaughterhouse. Rabbits delivered in containers should be handled with care during unloading and further handling. Uneven floors and faulty or poorly maintained equipment, such as forklifts, used in the movement of containers are prone to tipping or tilting of containers, potentially resulting in serious welfare consequences.

3.7.1.5. Slow down line speed

Description: faster line speeds (throughput rates) are not always conducive to maintaining good welfare, especially during handling and manual application of electrical stunning. When applying a higher throughput rate, staff is at risk of paying less attention to handling individual animals, and e.g. an effective and sufficiently long application of the electrical stun.

3.7.1.6. Report to managers

Description: Staff should be encouraged to report to managers any hazard in the slaughterhouse, in particular regarding broken or defective containers that may cause injuries to rabbits.

3.7.1.7. Proper machine construction

Description: Machines used for unloading and movement of containers should be constructed and maintained well to avoid loud noise, emissions, injuries, etc. (European Commission, 2017).

3.7.1.8. Regular calibration and maintenance of the equipment

Description: Electrical stunners should display the output voltage and the amount of current under load. For these displays to be accurate, the stunners should be regularly calibrated and maintained according to the manufacturer's instruction (European Commission, 2017). Failing to do so can have severe welfare consequences due to the use of inappropriate parameters leading to ineffective stunning or recovery of consciousness.

3.7.1.9. Adjust equipment accordingly

Description: Electrical parameters used for head-only or water bath stunning should lead to effective stunning; the outcome should be routinely monitored, and electrical stunning voltage/current output adjusted if necessary.

3.7.1.10. Monitor stun quality routinely

Description: The effectiveness of stunning should be routinely monitored to protect welfare of rabbits (European Commission, 2017). In this regard, a previous opinion published by EFSA AHAW Panel, 2013c–f provides guidance to key stages of monitoring and indicators of consciousness in other food animal species. Flow charts based on this are provided for rabbits in Section 3.6.3.

3.7.1.11. No preventive measures

Description: This refers to the situation that the only option to prevent the hazard is to change the method or to try to reduce the consequences of the hazard on the welfare of the rabbits (see mitigation measures to the welfare consequences, Section 3.6.1).

3.7.1.12. Proper monitoring

Description: Electrical stunners should measure and display the output voltage and the amount of current under load. Measuring units should be well maintained and calibrated on a regular basis.

3.7.1.13. Ensure equipment is fit for the purpose

Description: The choice of stunning equipment, especially captive bolt gun and associated bolt parameters (diameter, penetration depth, velocity), should be corrected for the species and size of rabbits to render them immediately unconscious.

The power of the cartridge, the compressed air line pressure and the spring should be appropriate for the species and size of rabbits. Cartridges should be stored in a dry place according to the manufacturer's instruction. Operator fatigue and overheating of the gun due to repeated firing in quick succession lead to poor welfare outcomes. There should be sufficient guns such that they are allowed to cool between operations, and they should be cleaned and maintained according to the manufacturer's instruction.

3.8. Response to ToR-4: specific hazards for animal categories

The European Commission mandates requests to point out specific hazards related to certain types rabbits. Some specific characteristics that may lead to additional hazards are:

- Long-haired breeds (e.g. Angora) may require clipping of hair over the temporal regions to minimise electrical resistance and improve efficacy, especially when using low voltages;
- Some breeds of rabbits have loose skin covering the forehead and extra care needs to be taken while placing captive bolts on their heads to prevent slipping or sliding of the bolt when fired;
- Some large breeds of rabbits (e.g. Flemish Giant) require modifications to stunning equipment;
- Breeds with large/floppy ears require care to prevent pre-stun shocks or mis-stun during captive bolt stunning
- The differences in shape and size of skulls between bucks and does may be more pronounced in some breeds, requiring additional attention during stunning.
- Animals reared in different farming systems (Cage vs Park pen) may react differently during handling, restraint and stunning.

3.9. Response to ToR5: suitable and unacceptable methods, procedures or practices on welfare grounds

The mandate requests to indicate suitability of stunning methods and to identify unacceptable methods in terms of welfare. The Panel considers that there are two problems with these requests. Firstly, the question of what practices are suitable or acceptable cannot be answered by scientific risk assessment, but rather involves e.g. ethical and socio-economic considerations that need to be weighed by the risk managers. Secondly, it has to be noted that methods, procedures or practices cannot be subjected to a risk assessment procedure if there is no published scientific evidence relating to them.

The Panel cannot currently give a scientific opinion on suitability of stunning methods, and therefore only the methods included in the EC Regulation 1099/2009 should be considered suitable for risk management reasons.

Regarding acceptability, chapter 7.5.10 of the OIE Terrestrial Animal Health Code (OIE, 2018) lists principles and practices it considers unacceptable, and the Panel has no scientific arguments to disagree with these statements.

3.10. Development of outcome tables linking hazards, preventive and corrective actions

Outcome tables were developed and include summarised information linking all the elements analysed to respond to the terms of reference of the opinion – i.e. hazards, welfare consequences, relevant indicators, hazards' origins, preventive and corrective actions. The outcome tables are intended as the main result of this scientific opinion with a concise presentation of all retrieved information. Detailed and supporting background information are included in the main chapters of this opinion.

3.10.1. Outcome tables related to the processes grouped in phase 1 – pre-stunning

This phase includes the following processes: arrival, unloading of the containers from the truck, lairage and handling and removing of rabbits from the containers. For each process, hazards, welfare consequences and relevant indicators and corrective measures; hazards' origin and preventive measures can be retrieved in Tables 18–21.

Table 18: Outcome table on **'arrival'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Too high effective temperature (see Section 3.5.1.1)	Heat stress	Equipment, facilities, staff	Lack of skilled operators, no protection from the environment, not enough ventilation in the truck, prolonged waiting time	• Staff training • Increase space allowance; • Scheduling to avoid hottest hours of the day for transport; • unload immediately following the arrival; • provide adequate ventilation to the truck at arrival place; • protect from adverse weather conditions.	Provide adequate ventilation, unload the truck immediately and bring the rabbits to a thermal neutral zone
Too low effective temperature (see Section 3.5.1.2)	Cold stress	Equipment, facilities, staff	Lack of skilled operators No protection from the environment (e.g. the absence of curtains in the truck, no heating system, etc.); prolonged waiting time	• Staff training • Before departure provide curtains and other protection and close the ventilation; • avoid coldest hours of the day for transport; • unload immediately following the arrival; • provide adequate shelter to the truck at arrival place.	Provide curtains or other protection when the rabbits are on the truck; unload the truck immediately and bring the rabbits to a thermal neutral zone (with heaters)
Insufficient space allowance (see Section 3.5.1.3)	Restriction of movements, heat stress	Staff	Lack of skilled operators Too many animals are put in the containers	• Staff training • Adjust the number of rabbits to size of the containers	None
Food deprivation too long (see Section 3.5.1.4)	Prolonged hunger	Staff	Lack of skilled operators Feeders removed too early on-farm, prolonged transport and/or prolonged waiting time	• Staff training • Planning of feed withdrawal on-farm according to duration of transportation and waiting time prior to slaughter; • scheduling slaughter of animals; • prioritising slaughter.	Provide food and water to the rabbits
Water deprivation too long (see Section 3.5.1.5)	Prolonged thirst	Staff	Lack of skilled operators Drinkers removed too early on-farm, prolonged transport and/or prolonged waiting time	• Staff training • Rabbits should have access to water till catching and loading in containers	Provide water to the rabbits
Indicators: panting (heat stress), reddening of the ears (heat stress), salivation (heat stress), death (heat stress, cold stress), shivering (cold stress), huddling (cold stress, restriction of movements), piloerection (cold stress), piling up (restriction of movements), no feasible indicators for prolonged hunger and thirst					

Table 19: Outcome table on **'unloading of containers from the truck'**: of hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Rough handling of containers (see Section 3.5.1.6)	Pain, fear	Staff, facilities	Lack of skilled operators Improper handling of containers; careless driving of forklifts; Dropping of containers; uneven floor.	• Training of staff for proper handling; • appropriate design and maintenance of facilities and equipment.	None
Indicators: injuries (pain), vocalisations (pain, fear)					

Table 20: Outcome table on **'lairage'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Too high effective temperature (see Section 3.5.1.1)	Heat stress	Equipment, facilities, staff	Environment, not enough ventilation in the truck, prolonged waiting time	• staff training • Increase space allowance; • Scheduling to avoid hottest hours of the day for transport; • unload immediately following arrival; • provide adequate ventilation to the truck at arrival place; • protect from adverse weather conditions. • increase the space between the containers in lairage	Provide adequate ventilation, unload the truck immediately and bring the rabbits to a thermal neutral zone.
Too low effective temperature (see Section 3.5.1.2)	Cold stress	Equipment, facilities, staff	no protection from the environment (e.g. no heating system, etc.); prolonged waiting time	• staff training • avoid coldest hours of the day for transport; • unload immediately following arrival; • provide adequate shelter to the truck at arrival place.	Unload the truck immediately and bring the rabbits to a thermal neutral zone (with heaters)

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Food deprivation too long (see Section 3.5.1.4)	Prolonged hunger	Staff	Prolonged waiting time	• staff training • scheduling slaughter of animals; • prioritising slaughter.	Provide food and water to the rabbits
Water deprivation too long (see Section 3.5.1.5)	Prolonged thirst	Staff	Drinkers removed too early on-farm, prolonged transport and/or prolonged waiting time	• staff training • rabbits should have access to water till catching and loading in containers	Provide water to the rabbits.
Unexpected loud noise (see Section 3.5.1.7)	Fear	Equipment, facilities, staff	Staff shouting, machine noise, poor design and layout of the facilities	• identify and eliminate the source of noise; • staff training; • avoid personnel shouting; • proper machine construction; • avoid noisy equipment close to the rabbits; • sound proofing of the facilities	None
Insufficient space allowance (see Section 3.5.1.3)	Restriction of movements, heat stress	Staff	Too many animals are put in the containers	• staff training • adjust the number of rabbits to size of the containers	None
Indicators: panting (heat stress), reddening of the ears (heat stress), salivation (heat stress), death (heat stress, cold stress), shivering (cold stress), huddling (cold stress, restriction of movements), piloerection (cold stress), piling up (restriction of movements), no feasible indicators for prolonged hunger and thirst, escape attempt or startling behaviour (fear), vocalisations (fear).					

Table 21: Outcome table on **'handling and removing of rabbits from crates or containers'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Rough handling of the rabbits during removal from the containers (see Section 3.5.1.8)	Pain, fear	Staff, facilities, equipment	Unskilled personnel; operator fatigue; high throughput rate, poorly designed containers (with small openings)	• staff training; • staff rotation; • change container system; • slow down line speed	None
Unexpected loud noise (see Section 3.5.1.7)	Fear	Equipment, facilities, staff	Staff shouting, machine noise, poor design and layout of the facilities	• identify and eliminate the source of noise; • staff training; • avoid personnel shouting; • proper machine construction; • avoid noisy equipment close to the rabbits; • sound proofing of the facilities	None

Indicators: injuries such as fractures, bruising, broken or dislocated spine (pain), vocalisations (pain and fear) escape attempt or startling behaviour (fear)

3.10.2. Outcome tables related to the processes grouped in phase 2 – stunning (stunning methods and relevant restraint, if any)

Table 22: Outcome table on **'head-only electrical stunning'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Manual restraint (see Section 3.5.2.1)	Pain, fear	Staff	Presentation of rabbits to the method is required	None	None
Inversion (see Section 3.5.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	Avoid the inversion of conscious animals	None
Shackling (see Section 3.5.2.3)	Pain, fear	Equipment	Depending on the choice of the slaughterhouse shackling may be part of the method	Avoid the shackling of conscious animals	None
Inappropriate shackling (see Section 3.5.2.4)	Pain, fear	Staff, equipment	Lack of skilled operators, operator fatigue, rough handling during catching, crating and uncrating, fast line speed, size and design of the shackle inappropriate for the rabbit size, force applied during shackling	• Staff training • Staff rotation • Appropriate number of people shackling to match the line speed • Shackle carefully • Size and design of shackle appropriate for bird sizes • Stun the rabbits before shackling • Kill injured rabbits before shackling	Shackle correctly
Poor electrical contact (see Section 3.5.2.5)	Consciousness, pain, fear	Staff, equipment	Lack of skilled operators, staff fatigue; incorrect placement of the electrodes; poorly designed, constructed and maintained equipment; intermittent contact; thickness of fur	• Staff training; • staff rotation; • ensure correct presentation of the rabbits, • ensure correct maintenance of the equipment; • ensure the equipment includes electrodes for different sized animals; • ensure continuous contact between the electrodes and the rabbits; • ensure regular calibration of equipment	None
Too short exposure time (see 3.5.2.6)	Consciousness, pain, fear	Staff	Lack of skilled operators, high throughput rate	• Staff training; • reduce throughput rate; • ensure a timer is built in the stunner to monitor the time of exposure or use of a visual or auditory warning system to alert the operator.	None

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Inappropriate electrical parameters (see Section 3.5.2.7)	Consciousness, pain, fear	Staff, equipment	Wrong choice of electrical parameters or equipment; poor or lack of calibration; voltage/current applied is too low; frequency applied is too high for the amount of current delivered; lack of skilled operators, lack of monitoring of stun quality; lack of adjustments to the settings to meet the requirements	• Use parameters appropriate to the frequency and waveforms of current; • ensure the voltage is sufficient to deliver minimum current; • regular calibration and maintenance of the equipment; • staff training; • consider the factors contributing to high electrical resistance and minimise–eliminate the source of high resistance; • monitor stun quality routinely and adjust the equipment accordingly; • use constant current source equipment; wetting the head of rabbits with a damp sponge	None
Indicators: injuries (pain), vocalisations (pain, fear), escape attempts (pain, fear) and indicators to assess the state of consciousness (see flow charts)					

Table 23: Outcome table on **'Controlled atmosphere stunning' method**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Exposure to too high CO2 concentration (see Section 3.5.2.12)	Pain, fear distress and respiratory distress	Staff, equipment	Lack of skilled operators, lack/poor calibration of monitors, poor administration of gas during injection.	• Staff training • Proper monitoring and maintenance of gas concentration • Maintenance and calibration of the equipment	Adjust gas concentration
Too short exposure time (see Section 3.5.2.6)	Consciousness distress and respiratory distress	Staff, equipment	Lack of skilled operators, lack of monitoring, line speed too high for the capacity of the slaughterhouse	• Staff training • Maintain adequate exposure time	Increase the exposure time until induction of unconsciousness

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Too low concentration of gas (see Section 3.5.2.11)	Consciousness distress and respiratory distress	Staff, equipment	Lack of skilled operators, lack of gas monitoring, property of the gas, concentration of the gas, uneven distribution of the gas, method of injection.	• Staff training • Adequate gas monitoring and maintenance of required concentration • Maintain adequate exposure time for the gas concentration • Maintenance and calibration of the equipment	Increase gas concentration until induction of unconsciousness
Indicators: escape attempts, head shaking, gasping and indicators to assess the state of consciousness (see flow charts)					

Table 24: Outcome table on **'captive bolt stunning'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Manual restraint (see Section 3.5.2.1)	Pain, fear	Staff	Presentation of rabbits to the method is required	None	None
Incorrect shooting position (see Section 3.5.2.8)	Consciousness, pain, fear	Staff	Lack of skilled operators, operator fatigue, poor presentation of rabbits, wrong angle of shooting	• Staff training and rotation, • appropriate restraint of the rabbit, • Stun in the correct position	None
Incorrect bolt parameters (see Section 3.5.2.9)	Consciousness, pain, fear	Staff, equipment	Lack of skilled operators, wrong choice of equipment, poor maintenance of the equipment, too narrow bolt diameter, shallow penetration, low bolt velocity	• Staff training, proper restraint of the rabbit, • ensuring equipment is fit for the purpose, • regular maintenance of equipment	None

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Inappropriate shackling (see Section 3.5.2.4)	Pain, fear	Staff, equipment	Lack of skilled operators, operator fatigue, rough handling during catching, crating and uncrating, fast line speed, size and design of the shackle inappropriate for the rabbit size, force applied during shackling	• Staff training • Staff rotation • Appropriate number of people shackling to match the line speed • Shackle carefully • Size and design of shackle appropriate for bird sizes • Stun the rabbits before shackling • Kill injured rabbits before shackling	Shackle correctly
Indicators: escape attempt (pain, fear, consciousness), injuries (pain), vocalisations (pain, fear) and indicators to assess the state of consciousness (see flow charts)					

Table 25: Outcome table on **'percussive blow'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Manual restraint (see Section 3.5.2.1)	Pain, fear	Staff	Presentation of rabbits to the method is required	None	None
Inversion (see Section 3.5.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	Avoid the inversion of conscious animals	None
Incorrect application (see Section 3.5.2.10)	Consciousness, pain, fear	Staff	Lack of skilled operators, operator fatigue, poor restraint, hitting in wrong place, insufficient force delivered to the head, wrong choice of tool to deliver the blow	Staff training and rotation	Correct application of the method
Indicators: injuries (pain), vocalisations (pain and fear), escape attempts (pain, fear) and indicators to assess the state of consciousness (see flow charts)					

3.10.3. Outcome tables related to the processes grouped in phase 3 – bleeding

Table 26: Outcome table on **'bleeding following stunning'**: hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard*	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Prolonged stun-to-neck-cut interval (see Section 3.5.3.1)	Consciousness, pain, fear	Staff, equipment (depending on the stunning method)	Lack of skilled operators; positioning of the stunner too far away from the neck-cutter	• Staff training; • prompt and accurate neck cutting; • ensuring back-up neck cutting; • reduce stun-to neck cutting interval	Apply back-up stunning before neck cutting
Incomplete sectioning of carotid arteries (see Section 3.5.3.2)	Consciousness, pain, fear	Staff, equipment	Lack of skilled operators, blunt knife,	• Training of staff, • use sharp knife, • ensure both carotid arteries are cut	Cut correctly both arteries
Neck cutting (see Section 3.5.3.3)	Pain	Staff	Lack of skilled operators, ineffective stun or recovering of consciousness before neck cutting, lack of monitoring of unconsciousness at the time of neck cutting	• Apply proper stunning and proper stun to stick interval. • Train the staff to monitor consciousness	Apply back up stunning before neck cutting
Repeated cuts (see Section 3.5.3.4)	Pain	Staff,	Lack of skilled operators, ineffective stun or recovering of consciousness before neck cutting and when both carotids are not severed during the first intervention	• Apply proper stunning and proper stun to stick interval • Train staff to monitor consciousness and use back-up method before re-cutting, • train the staff to adequately severe the carotids	None
Stimulation of wound (see Section 3.5.3.5)	Pain	Staff,	Lack of skilled operators, physical contact of the open wound due to the restraint or to the manipulation	• Staff training to avoid manipulating the wound	None

Hazard*	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Bleeding to death (see Section 3.5.3.6)	Pain, fear, distress	Staff, equipment	Lack of skilled operators, ineffective stun or recovering of consciousness during the bleeding	• Apply proper stunning and proper stun to stick interval • Train staff to monitor consciousness and use back-up method before re-cutting. • Train the staff to adequately severe the carotids	None
Dressing of rabbits while still alive (see Section 3.5.3.7)	Consciousness, pain, fear, distress, animal not death	Staff	Lack of skilled operators, SHORT bleeding time, incomplete section of both arteries; lack of monitoring of death before being dressed.	• Staff training • Ensuring death before being dressed	None
Indicators: attempt to regain posture (consciousness), escape attempts (pain, fear, consciousness), vocalisation (pain, fear), head shaking (pain), indicators to assess the state of consciousness and indicators of death (see flow charts)					

*: The hazards apply to only a portion of rabbits: those ineffectively stunned or recovering consciousness following stunning.

Table 27: Outcome table on '**bleeding during slaughter without stunning**': hazards, welfare consequences and relevant indicators; hazards' origin and preventive and corrective measures

Hazard (these hazards apply to all rabbits because they are conscious)	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Manual restraint (see Section 3.5.2.1)	Pain, fear	Staff	Requirement of the method	None	None
Inversion (see Section 3.5.2.2)	Pain, fear	Equipment	Requirement of the method, shackling or restraint in a cone	None	None
Shackling (see Section 3.5.2.3)	Pain, fear	Equipment	Requirement of the method	None	None

Hazard (these hazards apply to all rabbits because they are conscious)	Welfare consequence/s occurring to the rabbits due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s of hazards (implementation of SOP)	Corrective measure/s of the hazards
Inappropriate shackling (see Section 3.5.2.4)	Pain, fear	Staff, equipment	Lack of skilled operators, operator fatigue, rough handling during catching, size and design of the shackle inappropriate to the rabbit size, force applied during shackling	• Staff training, staff rotation, • shackle carefully, • size and design of shackle appropriate to rabbit sizes, • stun the rabbits before shackling, • kill injured rabbit before shackling • Appropriate number of people shackling to match the speed line	Shackle correctly
Neck cutting (see Section 3.5.3.3)	Pain	Staff	Neck cutting of conscious rabbits is a part of the method	None	None
Incomplete sectioning of carotids (see Section 3.5.3.2)	Pain, fear	Staff, Equipment	Lack of skilled operators, blunt knife	• Training of staff, • use sharp knife, • ensure both carotid arteries are cut	Cut correctly both arteries
Repeated cuts (see Section 3.5.3.4)	Pain, distress	Staff	Lack of skilled operators	• Training of staff to avoid repeated cut, • apply stunning	None
Stimulation of wound (see Section 3.5.3.5)	Pain	Staff	Lack of skilled operators, physical contact with the open wound due to the restraint or to the manipulation	• Staff training to avoid manipulating the wound • Adapt the equipment to avoid the physical contact with the wound	None
Bleeding to death (see Section 3.5.3.6)	Pain, fear, distress	Staff	Method requires inducing death through bleeding of conscious animals	None	None
Dressing of rabbits while still alive (see Section 3.5.3.7)	Consciousness, pain, fear, distress, animal not death	Staff	Lack of skilled operators, short bleeding time, incomplete section of both arteries; lack of monitoring of death before being dressed	• Staff training • Ensuring rabbits are dead before being dressed	None
Drops, curves and inclination of shackle line (see Section 3.5.3.8)	Pain, fear	Equipment, facility	Poor design, layout and construction of shackle line	Redesign shackle line to avoid these hazards	None
Indicators: escape attempts (pain, fear), tonic immobility (fear, distress), vocalisation (pain, fear), head shaking (pain), injuries (pain) and indicators of death (see flow charts)					

4. Conclusions

This scientific opinion responds to two mandates: one received from the European Parliament (EP) and the other received from the European Commission (EC). The opinion is dedicated to rabbits kept for meat production.

4.1. Conclusions for the European Parliament

In the context of the EP mandate, the scientific opinion focuses on stunning methods for rabbits, defines indicators to assess the state of consciousness and death and provides flow charts to support an indicator-based decision process. For the assessment of the indicators, their sensitivity (Se), specificity (Sp) and Ease of use were determined through an Expert Knowledge Elicitation (EKE) process. The uncertainty about the estimates obtained through the EKE was also estimated: Sp and Se in terms of a 90% certainty interval, and Easiness as a percentage of certainty relative to the level of agreement between experts.

The indicators were included in flow charts for each of three processes: captive bolt stunning, electric stunning and bleeding following slaughter with or without stunning. The flow charts allowed decisions to be taken on whether to proceed at the three key stages in the slaughter process.

A selection process was used to identify indicators that are recommended for each of these key stages. For this, the sensitivity (Se) was the most important parameter: only the three most sensitive indicators for each step were considered for the assessment of the state of consciousness. Specificity (Sp) was the most important aspect governing the selection of indicators of death (in order of decreasing width of the uncertainty interval). Two additional indicators are also proposed based on their ease of use.

As the Panel could not evaluate the suitability of stunning methods, it considers the only methods for stunning of rabbits to be used in the European Union are those allowed in the EC Regulation 1099/2009: head-only electrical stunning and the mechanical stunning with a captive bolt.

1) This opinion recognises three key stages for monitoring the state of consciousness: Key stage 1, immediately after stunning; Key stage 2, just prior to neck cutting; and Key stage 3, during bleeding.
2) For electrical and mechanical stunning methods, it was possible to identify three to four indicators for each of the key stages that are highly sensitive in identifying the state of consciousness and that should be used to monitor stunning effectiveness. Two additional indicators may also be used: these are not highly sensitive but were selected based on their ease of use. Estimates for sensitivity, ease of use and associated uncertainties can be found in Tables 14 and 15.
3) Poor bleeding practices lead to recovery of consciousness or to delayed onset of death. The opinion identifies animal welfare indicators to monitor onset of death in rabbits to be applied before bleeding following slaughter with or without stunning.
4) For bleeding, it was possible to identify three indicators that are highly specific to ensure that the animals are dead. Two additional indicators may also be used. The estimates for specificity, ease of use and associated uncertainties can be found in Table 16.

4.2. Conclusions for the European Commission

4.2.1. General conclusions

The mandate from the European Commission asks EFSA to provide an independent view on the slaughter of rabbits when killed for human consumption, covering all parts of the slaughter process. The scientific opinion focuses on the identification of hazards leading to negative rabbit welfare consequences at slaughter. The hazards, their origins, preventive and corrective measures, welfare consequences and related welfare indicators have been identified on the basis of literature search and expert opinion and taking into account the common slaughter practices and have been reported in the opinion.

Outcome tables have been prepared to summarise the main results of this opinion and include a concise presentation of all retrieved information.

Uncertainty in this context mainly relates to the possibility of i) incomplete listing of hazards, namely some welfare-related hazards may be missing in the identification process as considered not existing or not relevant (false negative); and ii) hazard not relevant for the welfare of rabbits at slaughter being included in the outcome tables (false positive).

The uncertainty analysis on the set of hazards for each process provided in this opinion revealed that the experts were 90–95% certain that they identified all welfare hazards considered in this assessment according to the three criteria described in the Interpretation of ToRs. However, when considering the situation worldwide, there is a 95–99% certainty that at least one welfare hazard is missing. At the same time, the experts were 95–99% certain that all listed hazards exist during slaughter of rabbits.

Similarly, uncertainty exists related to the possibility of incomplete or misclassified listing of hazard origins, preventive, corrective measures, welfare consequences and indicators, but owing to the limited time available to develop this scientific opinion, there is not an uncertainty analysis of this.

1) In total, 28 welfare-related hazards have been identified, from arrival of the rabbits at the slaughter plant until they are dead. Some of these hazards are common to different phases.
2) The hazards lead to welfare consequences. They may also interact with other hazards leading to a cumulative effect of the welfare consequence (e.g. pain due to injury caused by rough handling during catching will lead to more severe pain during restraint).
3) Exposure to some hazards might persist along processes and phases until the unconsciousness of the rabbits (e.g. food and water deprivation). Other hazards might be present only during one phase, but the welfare consequence might persist during the following phases (e.g. pain due to rough handling).
4) Rabbits will experience the negative welfare consequences of the hazards they are subjected to only in case they are conscious. 'Consciousness' is considered a welfare consequence after poor stunning, and a prerequisite for other welfare consequences the rabbits could experience, such as pain and fear.
5) The negative welfare consequences that rabbits can experience during the slaughter process are heat stress, cold stress, respiratory distress, prolonged thirst, prolonged hunger, restriction of movements, consciousness, animal not dead, pain, fear and distress.
6) All rabbits will experience the negative welfare consequences of the hazards happening during pre-stunning phase, restraint (when applied on conscious animals) and slaughter without stunning. Only a proportion of animals will be subjected to the negative welfare consequences due to hazards they will be exposed after stunning: these are the animals for which stunning was ineffective and/or which recovered consciousness before death.
7) Even when welfare consequences cannot be assessed at the slaughterhouse, it does not imply they do not exist.
8) Under certain circumstances, not all the indicators can be used (because of low feasibility) to determine the welfare consequences (e.g. at arrival/during lairage due to the accessibility to the animals in containers).
9) The opinion proposes preventive and corrective measures for the hazards identified for rabbits during the slaughter process; for most of the hazards, preventive measures can be put in place, whereas relevant corrective measures are not always available.
10) If not followed by adequate measures correcting the hazard, a welfare consequence will persist, until the animal is unconscious or dead.
11) The opinion proposes measures to mitigate the welfare consequences when no measures to correct the hazard exist.
12) A good design, layout and construction of the plant is considered a prerequisite to safeguard the welfare of rabbits. Even in a well-designed and equipped slaughter plant, training of staff is a key preventive measure to ensure the protection of animals.
13) In Phase 2 and 3, stun/re-stun with a back-up method or emergency killing are the methods to mitigate the welfare consequences.
14) Not all the methods, procedures and practices for slaughter of rabbits used worldwide are documented. Due to the lack of adequate description or scientific validation, a hazard analysis was not carried out for these methods, procedures or practices.

4.2.2. Conclusions specific Phase 1 – pre-stunning

Phase 1 (pre-stunning) includes the following processes: arrival, unloading, lairage and handling and removing of rabbits from crates or containers, and the information can be retrieved in Tables 18–21.

15) Eight hazards have been identified in this phase. All of them have staff as origin (ToR-1).
16) Some welfare consequences identified in phase 1 might be the result of the exposure to the hazards occurring on the farm and/or during transport (e.g. prolonged hunger) (ToR-2)
17) In the context of the slaughterhouse, some welfare consequences have no indicators (e.g. prolonged thirst), and others have indicators that are very difficult to assess while rabbits are inside the containers (e.g. fear). In these cases, emphasis should be given to the preventive measures (ToR-2)
18) Preventive measures can be put in place for all the hazards identified in this phase; but there are no corrective actions for four out of the eight hazards (ToR-3)
19) All preventive and corrective measures concern two domains: 1) the maintenance of the physiology of the rabbits (e.g. provide good ventilation to avoid heat stress), 2) the prevention/correction of pain and fear (e.g. gentle handling of the rabbits in containers and individually) (ToR-3)

4.2.3. Conclusions specific Phase 2 – stunning

Phase 2 (stunning) includes the following stunning methods (with relevant resstraint, if any): head-only electrical stunning, controlled atmosphere stunning, captive bolt stunning and percussive blow stunning. The information can be retrieved in Tables 22–25.

20) Twelve hazards have been identified in this phase. The number of hazards an animal can experience depends on the stunning method used. Most of the hazards lead to pain and fear, some of them also to distress and consciousness. Ten of them have staff as origin (ToR-1).
21) Electrical and mechanical methods induce immediate loss of consciousness but require restraint prior to stunning; when these methods are not properly applied, they can cause consciousness leading to pain, fear and distress as welfare consequences (ToR-1)
22) If stunning is not effective or animals recover consciousness following stunning, they will be hanging upside-down while conscious and this is physically abnormal and stressful for the animals (ToR-2).
23) In the context of phase 2, the same welfare consequences may be assessed by diverse indicators depending on the stunning method (e.g.) (ToR-2).
24) For some hazards, there are no corrective measures available (e.g. incorrect shooting position (ToR-3).

4.2.4. Conclusions specific Phase-3 – bleeding

Phase 3 – bleeding – includes bleeding following stunning and during slaughter without stunning. For the latter, it also includes restraint. Relevant information can be retrieved in Tables 26 and 27.

25) Twelve hazards have been identified in this phase. All the hazards lead to pain and fear, some of them also to distress and, in the case of bleeding following stunning, also to consciousness; nine of them have staff as origin (ToR-1).
26) Bleeding during slaughter without stunning will expose 100% of animals to hazards that will apply to bleeding phase (except the hazards leading to recovery of consciousness). In the case of bleeding following stunning, only a proportion of rabbits will be exposed to hazards occurring during bleeding: those that were incorrectly stunned and still conscious and those that recover consciousness prior to death (ToR-1).
27) Rabbits subjected to ineffective stunning or recovery of consciousness are experiencing the negative welfare consequences related to the hazards they are exposed to in phase 3. Pain will be the main welfare consequence experienced by these animals (ToR-2).
28) The activation of the nociceptive system occurring during neck cutting induces rabbits to experience severe pain (ToR-2).
29) A corrective measure is only available for the hazard 'incomplete sectioning of carotids' (ToR-3), and involves repeating the cut.
30) In bleeding following stunning, preventive measures can be put in place for all hazards, whereas, in the case of bleeding during slaughter without stunning, for some hazards there are no preventive measures other than to 'change the method', because the hazard is inextricably linked to the method (e.g. in the case of 'neck cutting') (ToR-3).

5. Recommendations

5.1. Recommendations for the European Parliament:

1) To reduce welfare risks due to poor stunning, it is important to assess the state of consciousness in order to detect the animals that are not properly stunned or recover consciousness after stunning.
2) To monitor stunning method efficacy, the state of consciousness of the animals should be checked at each of the three key stages – i.e. immediately after stunning, just prior to neck cutting and during bleeding – using the suggested indicators.
3) If animals show signs of consciousness, intervention needs to be applied i.e. re-stunning of the animals.
4) The opinion concludes that a set of indicators to be used to detect conscious animals following head-only electrical stunning in rabbits should consist of:

   Key stage 1 (immediately after stunning): corneal or palpebral reflex, tonic/clonic seizures, breathing. In addition, spontaneous blinking and vocalisation can be used but they should not be relied upon solely.
   Key stage 2 (just prior to neck cutting): corneal or palpebral reflex, tonic/clonic seizures, breathing and righting reflex. In addition, spontaneous blinking and vocalisation can be used but they should not be relied upon solely.
   Key stage 3 (during bleeding): corneal or palpebral reflex, breathing, tonic/clonic seizures and righting reflex. In addition, spontaneous blinking and vocalisation can be used, but it should not be relied upon solely.
5) The opinion concludes that a set of indicators (a minimum of two indicators) to be used to detect conscious animals following mechanical stunning of rabbits should consist of:

   Key stage 1 (immediately after stunning): corneal or palpebral reflex, breathing and tonic/clonic seizures. In addition, spontaneous blinking and vocalisation can be used but they should not be relied upon solely.
   Key stage 2 (just prior to neck cutting): corneal or palpebral reflex, breathing and righting reflex. In addition, spontaneous blinking and vocalisation can be used, but they should not be relied upon solely.
   Key stage 3 (during bleeding): corneal or palpebral reflex, breathing and righting reflex. In addition, spontaneous blinking and vocalisation can be used, but it should not be relied upon solely.
6) In the case of slaughter without stunning, it is important to assess the state of consciousness to confirm bleeding is proper leading to rapid onset of unconsciousness.
7) In both slaughter with and without stunning, death should be confirmed before dressing of the carcass.
8) If animals show signs of life at the beginning of carcass dressing, intervention needs to be applied i.e. post-cut stunning of the animals or cut completely both carotid arteries and wait for the animal to die.
9) Before dressing, the following indicators of death should be used: breathing, cessation of bleeding and muscle tone. In addition, heart beat and dilated pupils can be used, but they should not be relied upon solely.
10) More research is recommended for gas stunning of rabbits to establish concentration of gasses that causes minimum distress prior to loss of consciousness.

5.2. Recommendations for the European Commission

11) The presence of hazards should be monitored by assessing the welfare consequences through indicators; when a hazard is present, appropriate correctives measures should be applied (see outcome tables).
12) The welfare status of rabbits should be assessed at each phase of slaughtering to mitigate negative welfare consequences.
13) When use of some indicators is not feasible and the hazard is present, the related welfare consequences should be assumed to be experienced by the rabbits.
14) When a hazard is identified, it should be corrected as soon as possible.

15) The responsible person of the slaughterhouse should put in place adequate actions to prevent the occurrence of hazards. Such measures should include: i) the inspection and maintenance of containers, ii) training and rotation of the staff, iii) appropriate setting and use of the equipment (see outcome tables).
16) When no measures to correct the hazard exist, measures to mitigate the welfare consequences should be put in place.
17) All processes of the slaughtering should be carried out by trained and skilled personnel.
18) Rabbits delivered in containers should be removed one at a time from containers using both hands.
19) It is important to prevent rabbits to recover from stunning since it might expose them to hazards linked with bleeding, causing severe welfare consequences, such as consciousness which will lead to pain and fear.
20) To prevent rabbits to experience severe welfare consequences such as pain and fear:
    - animals should not be shackled whilst conscious,
    - animals should not be bled whilst conscious,
    - death must be monitored and confirmed in rabbits before being dressed.
21) The ranking of the hazards in terms of severity, magnitude and frequency of the welfare consequences of the rabbits at slaughtering should be done in order to be able to prioritise actions and improve the procedure at slaughter.

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Abbreviations

CAS	Controlled atmosphere stunning methods
DOA	Dead on arrival

EP	European Parliament
EKE	Expert Knowledge Elicitation
ECoGs	electrocorticograms
FBO	Food Business Operator
LAPS	Low Atmosphere Pressure Stunning
SOP	Standard operating procedures
WG	Working group

Appendix A – Literature search outcomes

As described in Section 2.2.1, a literature search was carried out to identify peer-reviewed scientific evidence on the topic of 'slaughter of rabbits' that could provide information on the elements requested by the ToRs, i.e.: description of the processes, identification of hazards, origins, preventive and corrective measures, welfare consequences and indicators).

To obtain this, firstly a broad literature search under the framework of 'welfare of rabbits at slaughter' was carried out, and the results were successively screened and refined as described below.

Sources of information included in the search: Bibliographic database 'Web of Science'.

The search string was designed to retrieve relevant documents to 'animal welfare' during 'slaughter and killing' of 'rabbits'. Restrictions applied in the search string related to the processes characterising 'slaughter and killing' (from arrival to bleeding) of animals in containers, and the date of publication (considering only those records published after EFSA, 2004). No language or document type restrictions were applied in the search string.

Table A.1: Date of the search: 19 December 2018

Web of science search string	
Years 2004–2019	
	Category
Search terms	**Field searched**
Rabbit* OR TS=lepor* OR TS=oryctolagus OR TS="oryctolagus cuniculus"	Topic
AND	
TS=slaughter* OR TS=kill* OR TS=stun*	Topic
AND	
TS=Arriv* OR TS=*load* OR TS=lairage* OR TS=handl* OR TS=mov* OR TS=restrain* OR TS=cut* OR TS=bleed* OR TS=conscious* OR TS=pain* OR TS=behav* OR TS=stress*	Topic
Welf* or "animal welfare"	Topic
Results: 53	
Results after screening	

Refinement of literature search results

The search yielded a total of 53 records that were exported to an EndNote library together with the relevant metadata (e.g. title, authors, abstract). Titles and abstracts were firstly screened to remove irrelevant publications (e.g. related to species, productive systems, processes and research purposes that were out of the scope of this opinion) and duplicates, and successively to identify their relevance to the topic.

Full text publications were screened if title and abstract did not allow assessing the relevance of a paper. The screening was performed by one reviewer, with support by a second reviewer in cases of doubt; publications that were not considered relevant nor providing any additional value to address the question were also removed. The screening led to 20 relevant records, which are reported in Table A.2.

Table A.2: List of publications relevant to 'slaughter of rabbits' resulting from the literature search

ID	Reference
1	Accorsi et al. (2017)
2	EFSA (2005)
3	EFSA (2006)
4	EFSA AHAW Panel (2013b)
5	EFSA AHAW Panel (2015)
6	Buil et al. (2004)
7	Caucci et al. (2018)
8	Dalmau et al. (2016)
9	De La Fuente et al. (2004)

ID	Reference
10	De la et al. (2007)
11	EFSA AHAW Panel (2011)
12	Liste et al. (2009)
13	Llonch et al. (2012)
14	Nakyinsige et al. (2014)
15	Nodari et al. (2009)
16	Petracci et al. (2010)
17	Trocino et al. (2018a)
18	Trocino et al. (2018b)
19	Verga et al. (2009)
20	Walsh et al. (2017)

Appendix B – Rationale about sensitivity and specificity of the indicators of unconsciousness and death

The use of animal-based indicators can be regarded in the same way as the use of a diagnostic test with either a positive or negative outcome. The performance of a test (i.e. the indicator) is usually described by its sensitivity and specificity. The estimation of sensitivity and specificity requires a definition of what can be considered a positive or negative outcome when checking for an indicator.

When monitoring the effectiveness of stunning, it is common to look for outcomes that indicate unconsciousness. However, in the slaughterhouse process, action is required when 'consciousness' is detected: e.g. animals will have to be re-stunned and/or the stunning process adjusted. Therefore, analogous to veterinary terms regarding the evaluation of diagnostic tests, the 'diseased status' is the 'presence of consciousness' and the 'non-diseased status' is the 'absence of consciousness'.

The definitions for the sensitivity and specificity of indicators differ depending on whether they are used in situations where animals are slaughtered with stunning or without stunning.

Sensitivity and specificity during slaughter with stunning

A positive outcome of the indicator (positive test) suggests that the animal is conscious. A negative outcome of the indicator (negative test) suggests the animal is unconscious.

Sensitivity is the percentage of truly conscious animals that the indicator correctly identifies as conscious. It is calculated as the number of truly conscious animals considered conscious based on the outcome of the indicator (A in Table B.1) divided by the total number of truly conscious animals (A + C), multiplied by 100.

Specificity is the percentage of truly unconscious animals that the indicator correctly identifies as unconscious. It is calculated as the number of truly unconscious animals considered unconscious based on the outcome of the indicator (D in Table B.1) divided by the total number of truly unconscious animals (B + D), multiplied by 100.

Table B.1: Sensitivity and specificity of indicators during slaughter with stunning

Slaughter with stunning		Truth: the animal is conscious	
		Yes	**No**
Is the animal considered conscious, based on the outcome of the indicator?	**Yes**	A	B
	No	C	D

An indicator for slaughter with prior stunning is considered to be 100 % sensitive if it detects all the conscious animals as conscious; an indicator is considered to be 100 % specific if it detects all the unconscious animals as unconscious.

Sensitivity and specificity for indicators of death, during slaughter with and without stunning

Prior to dressing, it is imperative to confirm death. In this case, the veterinary equivalent of the 'disease' that the test aims to determine is the presence of death of the animal.

A positive outcome of the checked indicator suggests the animal is dead. A negative test outcome of the indicator suggests the animal is alive.

In this case, the sensitivity is the percentage of dead animals that the indicator correctly identifies as dead. It is calculated as the number of dead animals considered dead based on the outcome of the indicator (E in Table B.2) divided by the total number of truly dead animals (E + G), multiplied by 100.

Specificity is the percentage of live animals that the indicator correctly identifies as alive. It is calculated as the number of live animals considered alive based on the outcome of the indicator (H in Table B.2) divided by the total number of live animals (H + F), multiplied by 100.

Table B.2: Sensitivity and specificity of indicators of death

Prior to dressing		Truth: the animal is dead	
		Yes	**No**
Is the animal considered dead, based on the outcome of the indicator?	**Yes**	E	F
	No	G	H

An indicator for death is considered to be 100% sensitive if it detects all dead animals as dead. An indicator is considered to be 100% specific if it detects all live animals as alive.

Appendix C – EKE methodology to estimate sensitivity, specificity and ease of use of the indicators

EKE Workshop

EKE is a systematic, documented and reviewable process to retrieve expert judgements from a group of experts. The EFSA Guidance on EKE (EFSA, 2014) provides detailed protocols for obtaining expert judgement in the areas covered by EFSA's food safety remit. Several EKE methods exist to elicit expert judgement, for instance:

- Delphi method: this is an iterative survey including feedback from the involved experts over successive rounds. It allows the involvement of a large number of experts, as the experts answering individually in written format. The inaction between experts is limited to their written reasoning.
- Sheffield method: it is designed to elicit the knowledge of a group of experts in a face-to-face elicitation workshop, with the result being a distribution representing the aggregated judgements of the experts. The process enables the group to open discuss the question and agree on a reasoning. The number of involved expert is limited.

In this opinion, a two-step approach was used following a combination of the Delphi and the Sheffield methods. A survey in a group of about 25 experts (food business operators and researchers) was conducted using an online survey platform to gather information regarding the use of indicators to assess the state of unconsciousness or death in rabbits. Questions about sensitivity, specificity and ease of use, of the indicators were asked for monitoring of electric stunning, mechanical stunning and slaughter without stunning.

The survey result was analysed for inconsistencies and summarised as preparation of a Sheffield workshop.

Subsequently, a smaller group of 10 experts was invited to an EKE workshop to revise and discuss the results of the survey. After the discussion, the experts were asked for their individual judgements on sensitivity, specificity and ease of use, of the indicators. As a result of the discussion, some questions were further split (e.g. for the different phases of the stunning process), or merged, when no differences were obtained during the discussion.

The workshop was held on 9 and 10 April 2019 with eight external experts that had previously participated to the online survey mentioned above. The external experts were selected based on their background (e.g. food business operators or researchers), competence (e.g. electric or mechanical methods) and country of origin (i.e. ensuring that all four major EU rabbit producers are represented). Two working group experts were included to incorporate the discussions within the working group and balance the composition of the elicitation group. The purpose of the meeting was to discuss and revise the values for sensitivity, specificity and ease of use of the indicators obtained by the survey.

In particular, the information about sensitivity and specificity of the indicators was elicited by asking respondents to estimate, for each indicator, the proportion of truly conscious and the proportion of truly unconscious animals that would be considered conscious or unconscious, based on the outcome of the indicator. Similar questions were raised for slaughter without stunning.

With stunning:

Assuming 100 rabbits being truly conscious after stunning.
On European average, how many of them will be recognised as conscious by the indicator? [0–100]

Assuming 100 rabbits being truly unconscious after stunning.
On European average, how many of them will be recognised as unconscious by the indicator? [0–100]

Without stunning:

Assuming 100 rabbits being truly dead after neck cutting.
On European average, how many of them will be recognised as dead by the indicator? [0–100]

Assuming 100 rabbits being truly alive after neck cutting.
On European average, how many of them will be recognised as alive by the indicator? [0–100]

The discussion focussed on reasons for possible low/high sensitivity or low/high specificity of the indicators, variations between slaughterhouses/practices and uncertainties on the circumstances in Europe. Scenarios were build, to explain low/high values. Tendencies for low/high values were discussed.

For each question, the experts were asked to give a reasonable range, e.g. for the minimal/maximal value of the average sensitivity in Europe. They were further asked to judge on their believe probability that this range includes the unknown true value. Finally, the experts were judging on a median value, that neither over- nor underestimated the unknown true value.

Regarding ease of use, questions were asked on how easily the indicators are applied and checked during the stunning and slaughter process using three categories: easy, moderate and difficult (to apply). The discussion within the group was used to guarantee a comparable approach between the indicators.

Values for ease of use of the indicators were assessed for three key stages: Phase 1: immediately after stunning, before shackling: Phase 2: at the time of neck cutting and Phase 3: during bleeding.

It was agreed to assume that the operators are well trained and the slaughterhouses are equipped according to EU law.

Outcome of the EKE workshop

During the EKE workshop, the discussion focussed on reasons for possible low/high sensitivity or low/high specificity of the indicators, variations between slaughterhouses/practices and uncertainties on the circumstances in Europe. Scenarios were constructed to explain low/high values. Tendencies for low/high values were discussed.

For each question, the experts were asked to give a reasonable range, e.g. for the minimal/maximal value of the average sensitivity in Europe. They were further asked to state their judgement of probability that this range includes the unknown true value. Finally, the experts were asked to state a median value, that neither over- nor underestimated the unknown true value.

The answers of the experts were aggregated afterwards to construct the common uncertainty distribution. According to the EKE guidance, this was done using an equal weighted superimposition of the individual answers (range, coverage and median), followed by a fitting of a Beta-distribution to smooth the outcome. See Figure C.1.

Individual answer: Aggregated experts: Fitted smooth distribution:

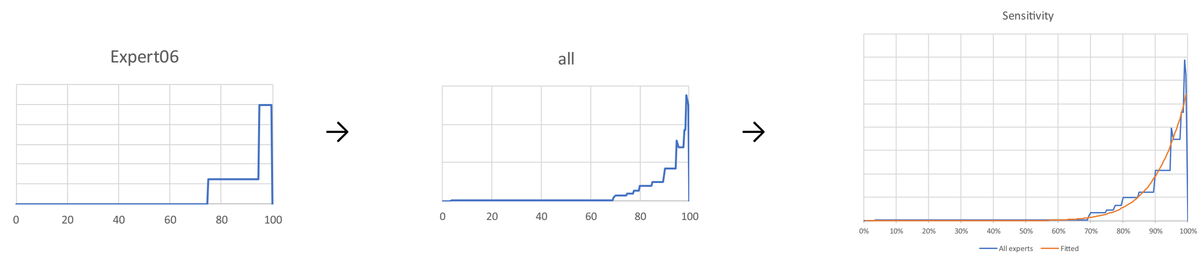


Figure C.1: process of fitting of a Beta-distribution to smooth the outcome

The Beta distribution was used to calculate the median and 90% uncertainty range of the common judgement.

Uncertainty analysis about the easiness to apply an indicator

For the ease of application, the categories were scored with 1, 2 and 3 as follows:

Table C.1: Category codes for ease of application

Category	**Score**
Easy	1
Moderate (Normal)	2
Difficult	3

The uncertainty of the judgement is expressed as the distribution of individual answers within the expert group from which a single measure of certainty (based on the standard deviation) was derived.

An example is presented below in Table C.2 for the indicator 'easiness during bleeding'. In this example, three experts judged it as easy, three experts judged it to be moderate and four as difficult to assess.

Table C.2: Example of distribution of judgements for ease of application of an indicator

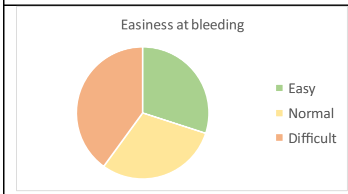
Distribution of judgements		
		3 experts: Easy (score of 1) 3 experts: Moderate (score of 2) 4 experts: Difficult (score of 3)
		Average: ((3*1)+(3*2)+(4*3)) / 10 = 2.1

Table C.3: Translation of the average answer into a category for ease of application

Average	**Easiness**
$1 \leq x \leq 1.67$	Easy
$1.67 < x \leq 2.33$	Moderate
$2.33 < x \leq 3$	Difficult

The average value was then used for the final judgement, as follows:

In this example, the final judgement about easiness of this indicator would be 'Moderate'.

The uncertainty within the judgements of 'Easiness of application' is described as the relative standard deviation of the mean average given the observed distribution:

Uncertainty = STD((X1*1 + X2*2 + X3*3)/N)/STD((Z1*1 + Z2*2 + Z3*3)/N)
with (X1, X2, X3) ≈ Multinomial(N, (p1, p2, p3))
(Z1, Z2, Z3) ≈ Multinomial(N, (1/3, 1/3, 1/3))
N = Number of experts
(p1, p2, p3) = Result of the elicitation
Pi = ki/N Proportion of experts judging for Easiness 'i'

This measure is 0%, if all experts give the same judgement, and it is 100%, if all judgements are randomly (equally) distributed to the categories.

To support the interpretation, following classes are used:

80% ≤ uncertainty ≤ 100% is regarded as high uncertainty;
50% < uncertainty < 80% is regarded as medium uncertainty;
0% ≤ uncertainty ≤ 50% is regarded as low certainty.

In the example, the uncertainty would be 'High' (83%).

The outcome of this elicitation was finally summarised in seven Graphs, in which the median sensitivity, median specificity and average ease of use of the selected indicators are shown:

- Electric stunning: phase 1, phase 2, phase 3
- Mechanical stunning: phase 1 phase 2, phase 3
- Slaughter without stunning

Only for the indicator 'tonic-clonic seizure', it was decided to assess the sensitivity and specificity for each key stage as it was agreed that these parameters will change noticeably during the slaughter process. For the other indicators, the specificity and sensitivity were judged only once. The ease of use was assessed for each key stage by the experts and is expressed by different colours (green = easy, orange = moderate, red = difficult).

For each key stage, one graph was produced. Below the graphs are reported of the two stunning methods (head-only electrical stunning and captive bolt stunning), as well as for indicators of death.

Graphs for indicator selection for the three key stages for head-only electrical stunning

Each indicator corresponds to a dot in the graph placed in the position of the resulted values for sensitivity (x-axis) and specificity (y-axis). The ease of use is expressed by different colours (green = easy, orange = moderate, red = difficult).

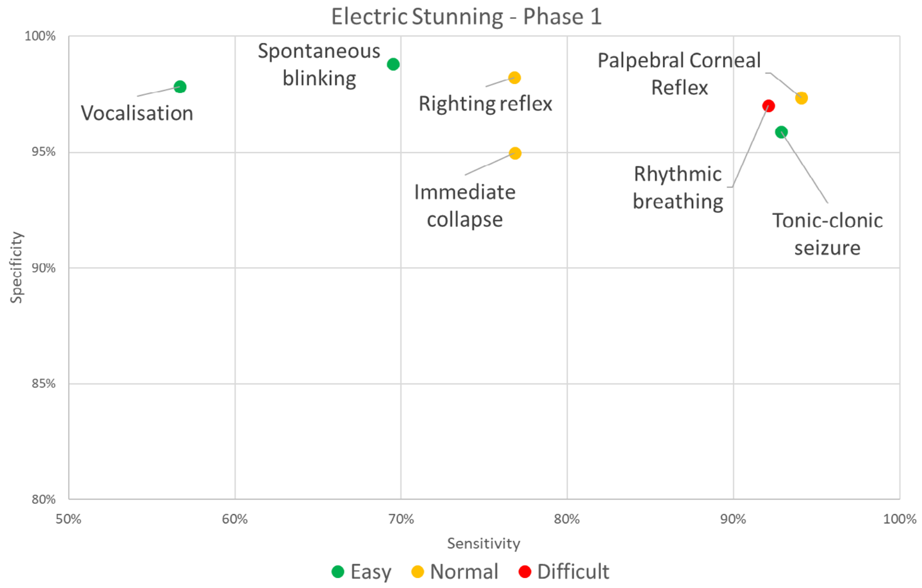


Figure C.2: Head-only electrical stunning, Phase 1 – immediately after stunning

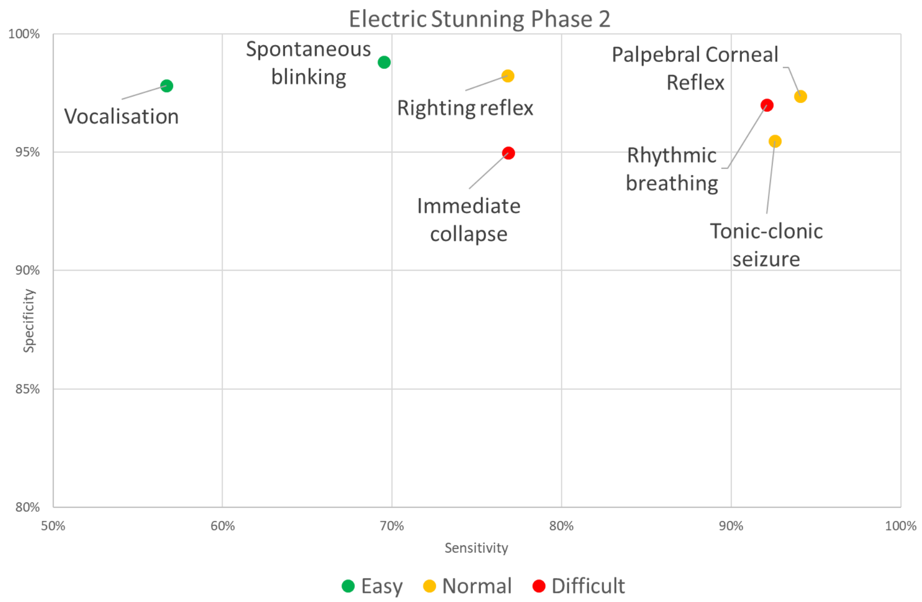


Figure C.3: Head-only electrical stunning, Phase 2 – before neck cutting

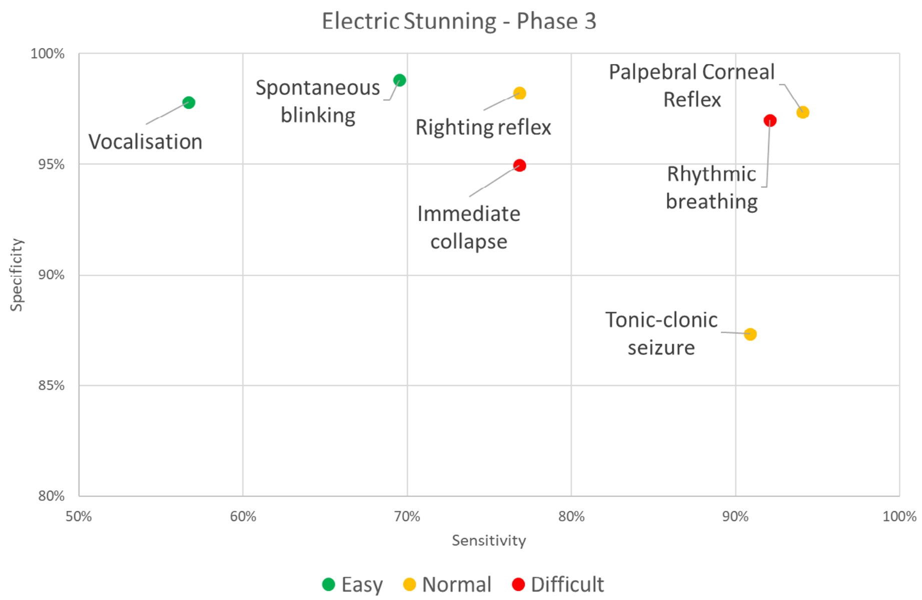


Figure C.4: Head-only electrical stunning, Phase 3 – during bleeding

Graphs for indicator selection for the three key stages for captive bolt stunning

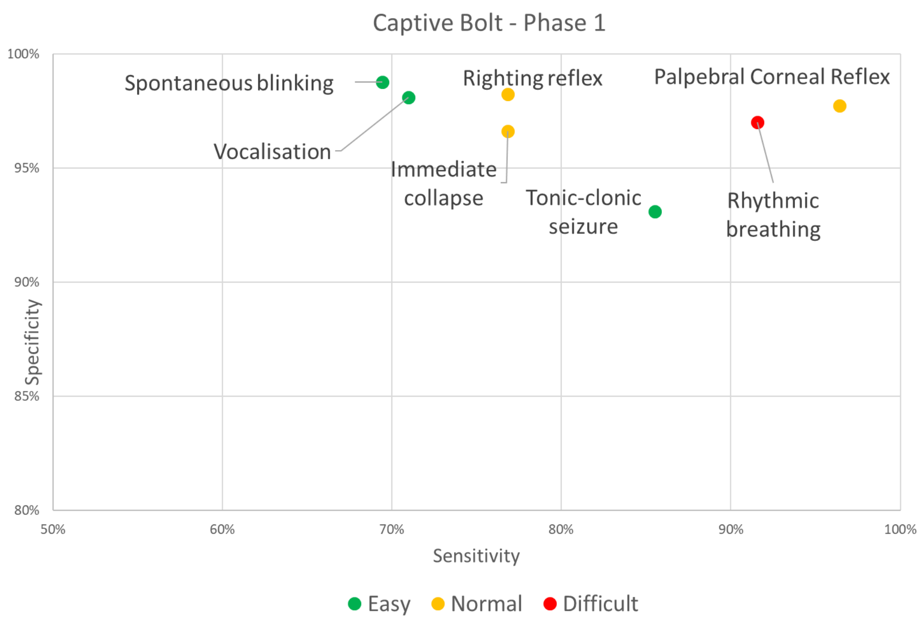


Figure C.5: captive bolt stunning, Phase 1 – immediately after stunning

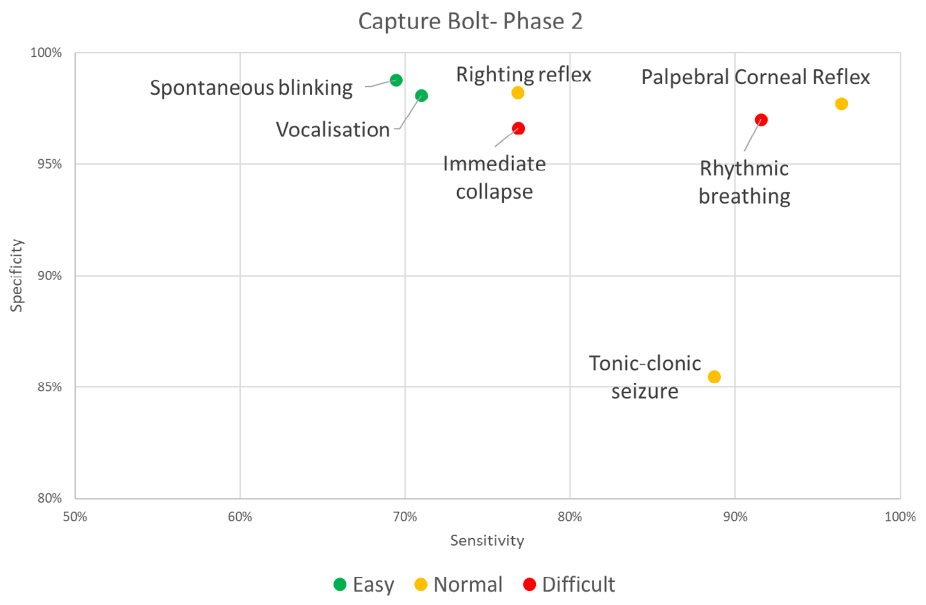


Figure C.6: captive bolt stunning, Phase 2 – before neck cutting

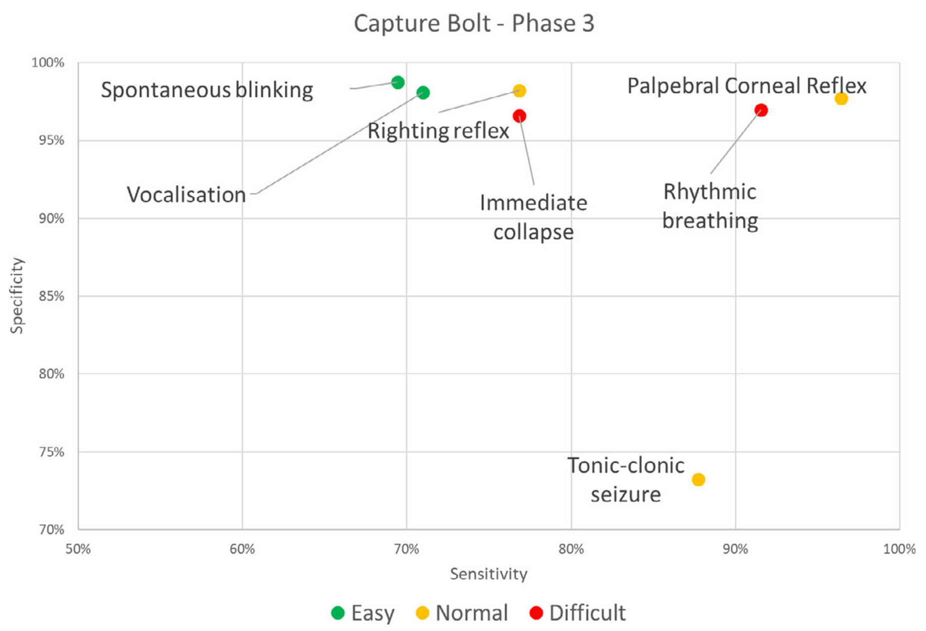


Figure C.7: captive bolt stunning, Phase 2 – before bleeding

Graphs for indicator selection for bleeding during slaughter without stunning

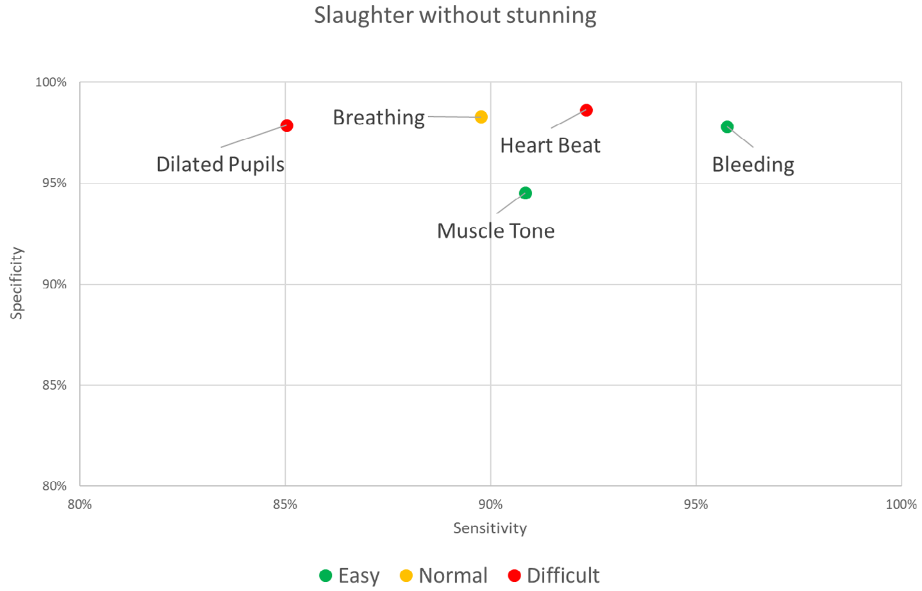


Figure C.8: slaughter without stunning – indicators of death

Results of the EKE Workshop

Abbreviations used in the tables:

Stunning methods:

- Elec = 'Head-only electric stunning'
- CaBo = 'Captive bolt mechanical stunning'
- NoSt = 'Without stunning'

Indicator for consciousness:

- ToCl = 'Tonic-clonic seizure'
- PaCo = 'Palpebral and corneal reflex'
- SpBl = 'Spontaneous blinking'
- RhBr = 'Rhythmic breathing'
- RiRe = 'Righting reflex'
- ImCo = 'Immediate collapse'
- Voca = 'Vocalisation'

Indicators for death:

- DiPu = 'Dilated pupils'
- HeBe = 'Heart beat'
- Brea = 'Breathing'
- Blee = 'Bleeding'
- MuTo = 'Muscle tone'

Phases in the stunning process:

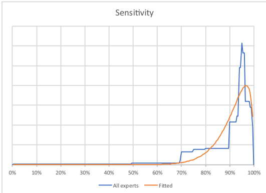
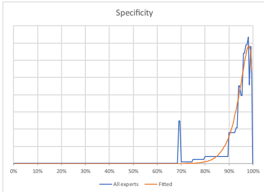
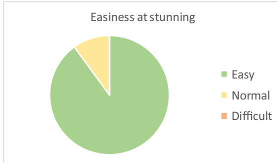
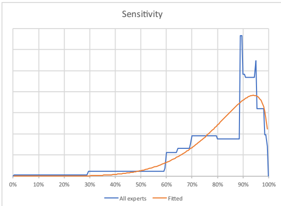
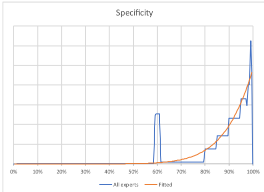
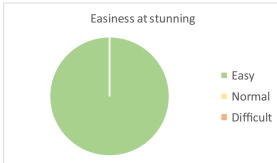
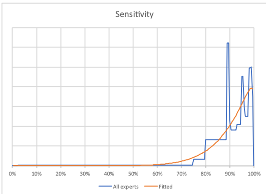
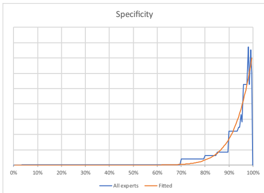
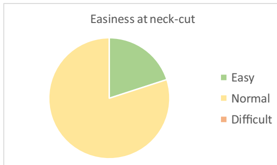
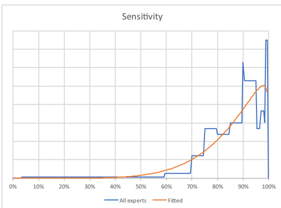
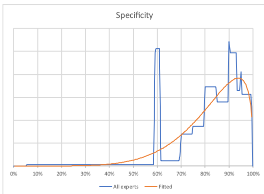
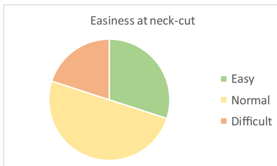
- Phase 1 = 'Immediately after stunning, before shackling'
- Phase 2 = 'At the time of neck cutting'
- Phase 3 = 'During bleeding'

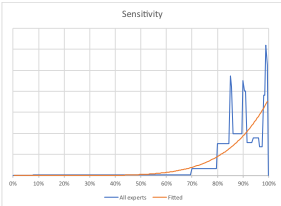
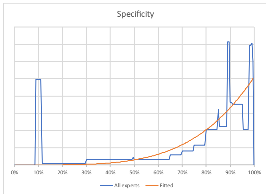
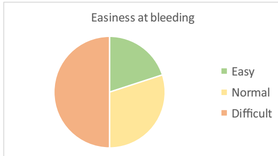
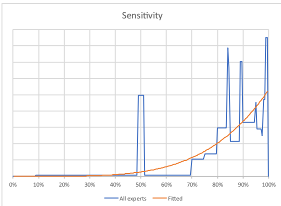
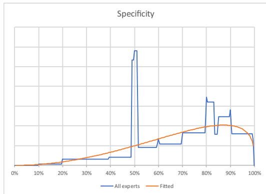
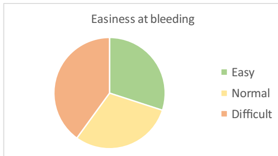
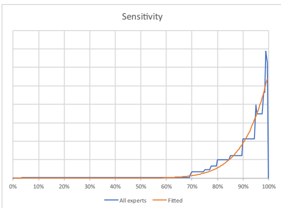
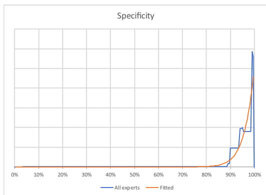
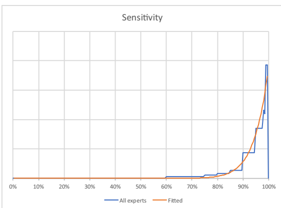
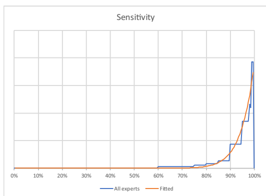
Table C.4: Sensitivity, specificity [Median and 90% uncertainty range], and easiness [average category] of indicators during slaughter per phase of the slaughter process, if applicable

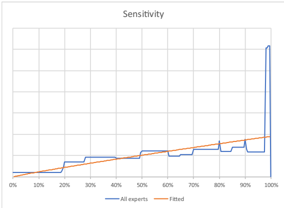
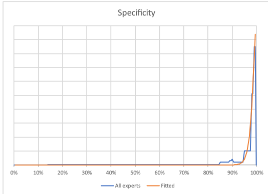
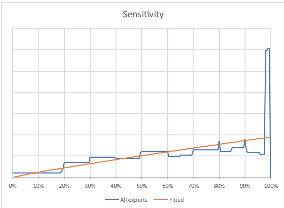
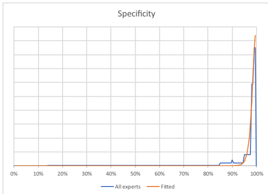
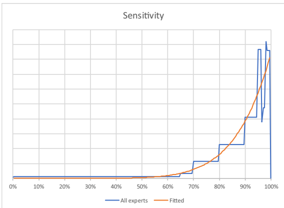
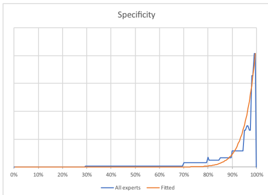
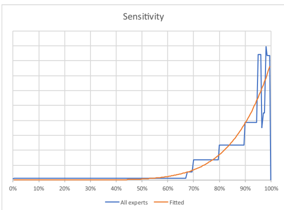
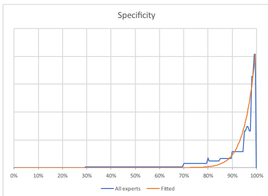
Stunning	Indicator	Phase	Sensitivity			Specificity			Easiness of application		
			Results								
			Median	P5	P95	Median	P5	P95	Phase 1	Phase 2	Phase 3
			[%]	[%]	[%]	[%]	[%]	[%]	Average category		
Elec	**ToCl**	**Phase 1**	92.9%	78.2%	98.9%	95.9%	86.7%	99.4%	1.1		
CaBo			85.5%	57.4%	98.0%	93.1%	73.5%	99.5%	1.0		
Elec		**Phase 2**	92.6%	73.1%	99.3%	95.5%	81.9%	99.7%		1.8	
CaBo			88.7%	62.0%	98.9%	85.5%	57.7%	98.0%		1.9	
Elec		**Phase 3**	90.9%	66.1%	99.3%	87.3%	55.7%	99.0%			2.3
CaBo			87.7%	56.8%	99.0%	73.3%	32.4%	96.4%			2.1
Elec	**PaCo**		94.1%	76.8%	99.5%	97.4%	89.1%	99.8%	2.3	2.0	2.1
CaBo			96.4%	85.4%	99.7%	97.7%	90.6%	99.8%	1.9	1.9	2.1
Elec	**SpBl**		69.5%	20.8%	97.3%	98.8%	95.8%	99.9%	1.5	1.4	1.4
CaBo			69.4%	20.7%	97.3%	98.8%	96.1%	99.8%	1.4	1.1	1.4
Elec	**RhBr**		92.1%	70.0%	99.4%	97.0%	87.7%	99.8%	2.6	2.6	2.5
CaBo			91.6%	68.3%	99.3%	97.0%	87.7%	99.8%	2.6	2.6	2.5
Elec	**RiRe**		76.8%	34.9%	97.6%	98.2%	92.6%	99.9%	1.7	2.1	2.2
CaBo			76.8%	34.9%	97.6%	98.2%	92.6%	99.9%	1.7	2.1	2.2
Elec	**ImCo**		76.8%	32.0%	98.1%	95.0%	80.0%	99.6%	2.1	3.0	3.0
CaBo			76.8%	32.0%	98.1%	96.6%	86.2%	99.7%	1.9	3.0	3.0
Elec	**Voca**		56.7%	8.6%	95.9%	97.8%	90.9%	99.8%	1.0	1.1	1.1
CaBo			71.0%	37.0%	93.3%	98.1%	92.0%	99.9%	1.0	1.2	1.2
NoSt	**DiPu**		85.0%	49.6%	98.8%	97.9%	91.2%	99.8%	2.4		
	HeBe		92.3%	71.2%	99.4%	98.7%	94.3%	99.9%	2.7		
	Brea		89.8%	62.7%	99.2%	98.3%	92.9%	99.9%	2.3		
	Blee		95.8%	82.9%	99.7%	97.8%	91.0%	99.8%	1.1		
	MuTo		90.8%	66.0%	99.3%	94.5%	78.5%	99.6%	1.0		

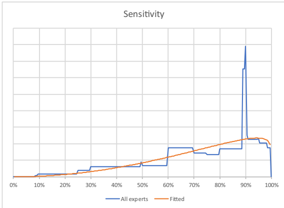
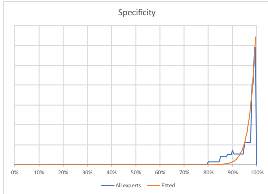
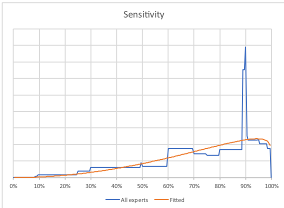
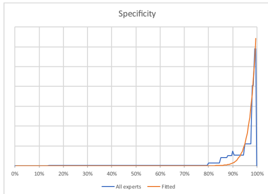
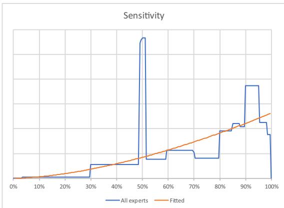
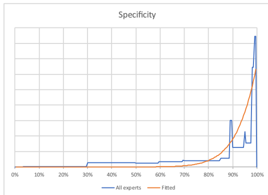
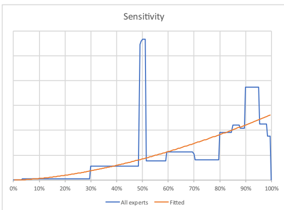
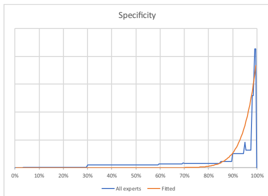
Categories of Easiness: 'Easy/green' = 1.0 ≤ × ≤ 1.66, 'Normal/yellow' = 1.66 < × ≤ 2.33, 'Difficult/red' = 2.33 < × ≤ 3.0.

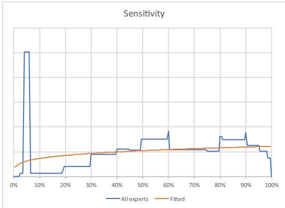
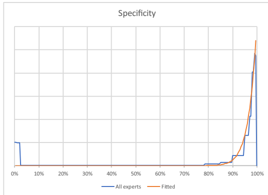
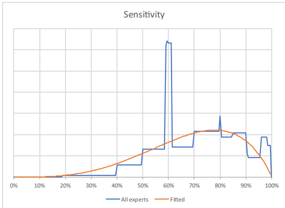
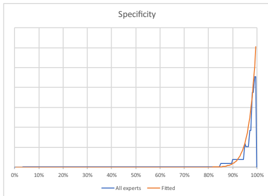
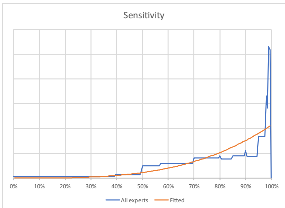
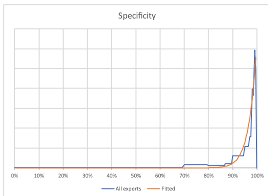
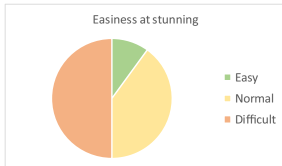
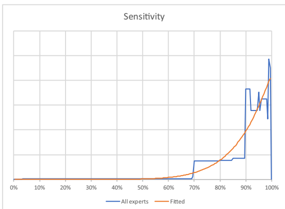
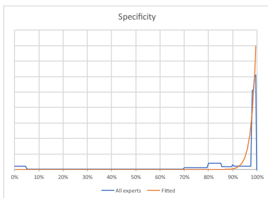
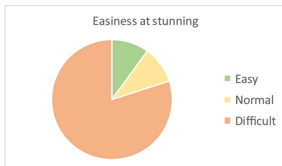
Table C.5: Uncertainty distribution of sensitivity, specificity and easiness of indicators during slaughter per phase of the slaughter process, if applicable

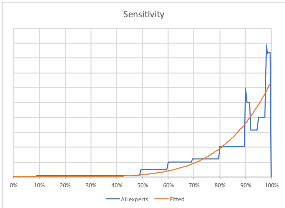
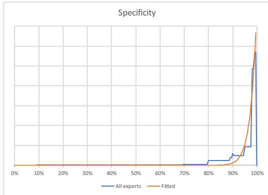
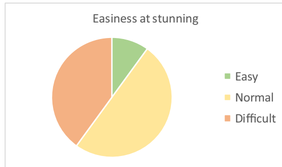
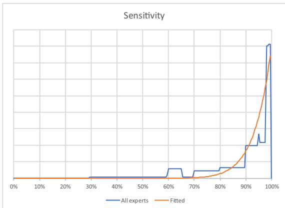
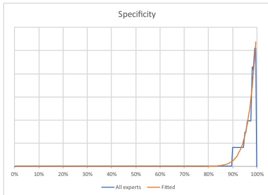
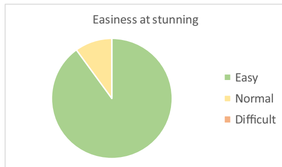
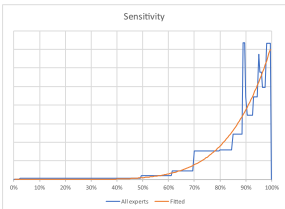
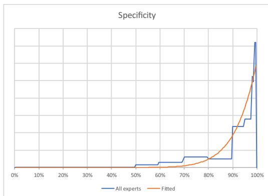
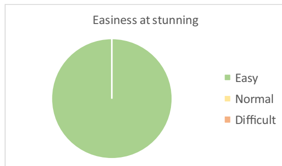
Stunning	Indicator	Phase	Sensitivity	Specificity	Easiness of application		
			Distributions				
			Judged vs. fitted distribution		Answers		
					Easy	Normal	Difficult
Elec	ToCl	Phase 1	Beta(15.5,1.4792)	Beta(26.491,1.443)	9	1	0
					Certainty=70%		High
							
CaBo			Beta(6.386,1.3404)	Beta(9.7131,1)	10	0	0
					Certainty=100%		High
							
Elec		Phase 2	Beta(10.022,1.0849)	Beta(15.021,1.0001)	2	8	0
					Certainty=60%		High
							
CaBo			Beta(6.6895,1.1181)	Beta(6.4876,1.3598)	3	5	2
					Certainty=30%		Medium
							

Stunning	Indicator	Phase	Sensitivity	Specificity	Easiness of application		
			Distributions				
			Judged vs. fitted distribution		Answers		
					Easy	Normal	Difficult
Elec	ToCl	Phase 3	Beta(7.2397,1)	Beta(5.1134,1)	2	3	5
					Certainty=22%		Medium
							
aBo			Beta(5.2926,1)	Beta(3.0213,1.2963)	3	3	4
					Certainty=17%		Low
							
Elec	PaCo		Beta(11.357,1)	Beta(25.942,1)			
					See below		
CaBo			Beta(18.947,1)	Beta(30.334,1)			
					See below		

Stunning	Indicator	Phase	Sensitivity	Specificity	Easiness of application		
			Distributions				
			Judged vs. fitted distribution		Answers		
					Easy	Normal	Difficult
Elec	SpBl		Beta(1.9074,1)	Beta(84.679,1.3331)			
					See below		
CaBo			Beta(1.9003,1)	Beta(103.19,1.596)			
					See below		
Elec	RhBr		Beta(8.4008,1)	Beta(22.751,1)			
					See below		
CaBo			Beta(7.8589,1)	Beta(22.751,1)			
					See below		

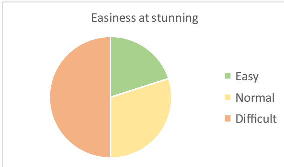
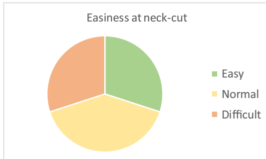
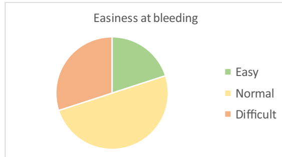
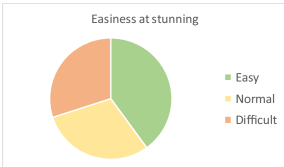
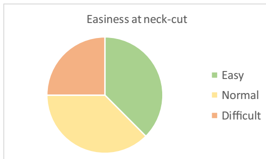
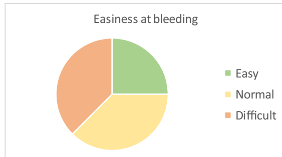
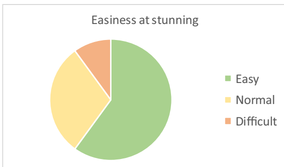
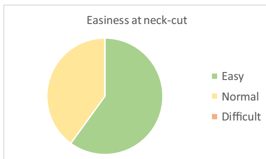
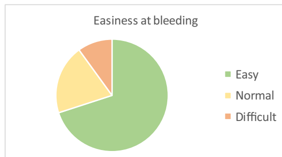
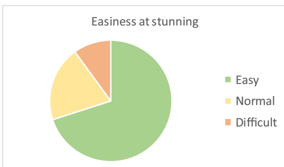
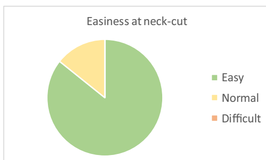
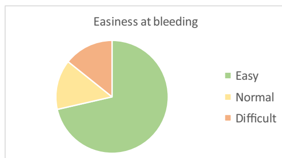
Stunning	Indicator	Phase	Sensitivity	Specificity	Easiness of application		
			Distributions				
			Judged vs. fitted distribution		Answers		
					Easy	Normal	Difficult
Elec	RiRe		Beta(3.0091,1.1181)	Beta(38.835,1)			
					See below		
CaBo	RiRe		Beta(3.0091,1.1181)	Beta(38.835,1)			
					See below		
Elec	imCo		Beta(2.6307,1)	Beta(13.422,1)			
					See below		
CaBo	imCo		Beta(2.6307,1)	Beta(20.202,1)			
					See below		

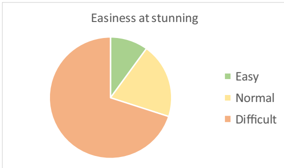
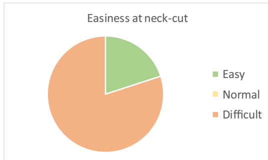
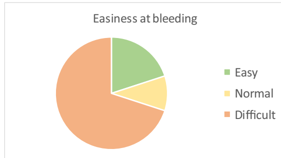
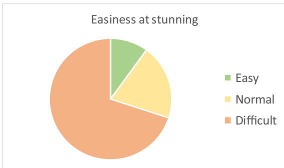
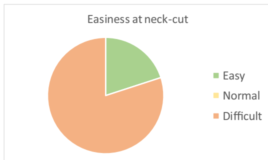
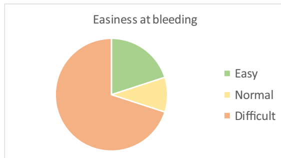
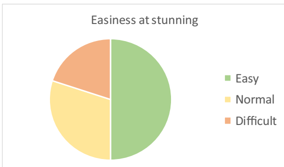
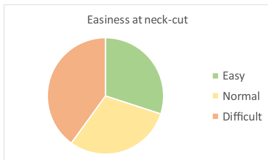
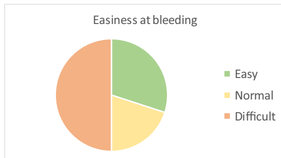
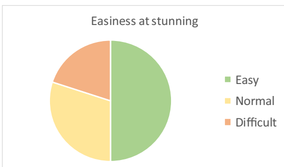
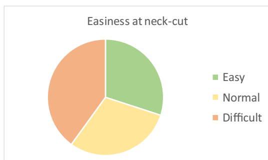
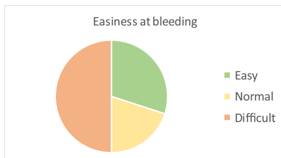
Stunning	Indicator	Phase	Sensitivity	Specificity	Easiness of application		
			Distributions				
			Judged vs. fitted distribution		Answers		
					Easy	Normal	Difficult
Elec	Voca		Beta(1.2211,1)	Beta(31.379,1)			
					See below		
CaBo			Beta(4.2472,1.9219)	Beta(36.004,1)			
					See below		
NoSt	DiPu		Beta(4.2737,1)	Beta(32.496,1)	1	4	5
					Certainty=34%		Medium
							
	HeBe		Beta(8.9137,1.0195)	Beta(51.156,1)	1	1	8
					Certainty=36%		Medium
							

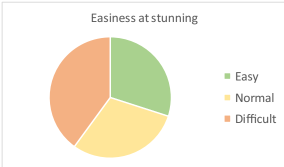
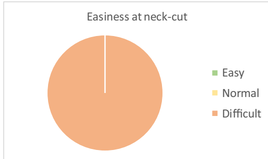
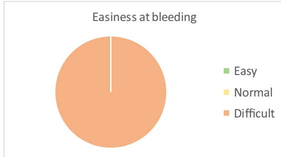
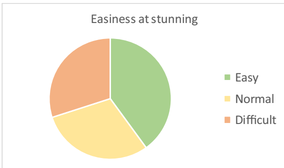
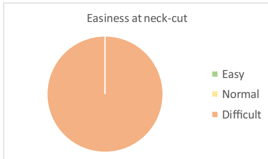
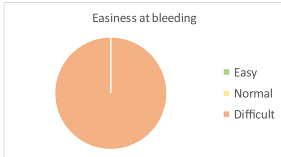
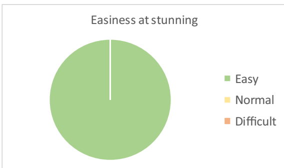
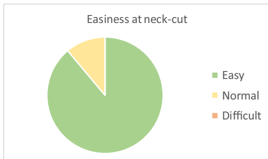
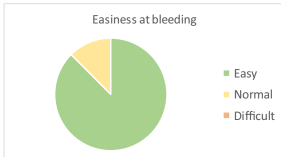
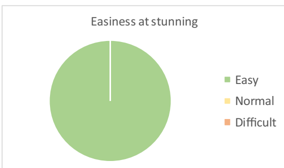
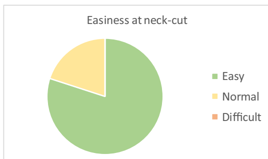
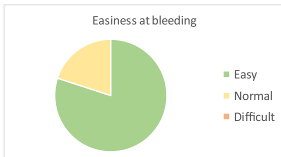
Stunning	Indicator	Phase	Sensitivity	Specificity	Easiness of application		
			Distributions				
			Judged vs. fitted distribution		Answers		
					Easy	Normal	Difficult
NoSt	Brea		Beta(6.4201,1)	Beta(40.647,1)	1	5	4
					Certainty=36%		Medium
							
	Blee		Beta(15.965,1)	Beta(15.965,1)	9	1	0
					Certainty=70%		High
							
	MuTo		Beta(7.2132,1)	Beta(12.343,1)	10	0	0
					Certainty=100%		High
							

The certainty within the judgements of 'Easiness of application' is described with 1 minus the relative standard deviation of the mean assuming the observed distribution. To support the interpretation, following classes are used:

0% ≤ certainty ≤ 20% – low/20% < certainty < 50% – medium/50% ≤ certainty ≤ 100% – high

Stunning	Indicator	Phase							Easiness of application		
			Distributions								
			Phase 1: Stunning			Phase 2: Neck-cut			Phase 3: Bleeding		
			Answers			Answers			Answers		
			Easy	Normal	Difficult	Easy	Normal	Difficult	Easy	Normal	Difficult
Elec	PaCo		2	3	5	3	4	3	2	5	3
			Certainty=22%		Medium	Certainty=23%		Medium	Certainty=30%		Medium
											
CaBo			4	3	3	3	3	2	2	3	3
			Certainty=17%		Low	Certainty=22%		Medium	Certainty=22%		Medium
											
Elec	SpBl		6	3	1	6	4	0	7	2	1
			Certainty=33%		Medium	Certainty=51%		High	Certainty=34%		Medium
											
CaBo			7	2	1	6	1	0	5	1	1
			Certainty=34%		Medium	Certainty=65%		High	Certainty=27%		Medium
											

Stunning	Indicator	Phase							Easiness of application		
			Distributions								
			Phase 1: Stunning			Phase 2: Neck-cut			Phase 3: Bleeding		
			Answers			Answers			Answers		
			Easy	Normal	Difficult	Easy	Normal	Difficult	Easy	Normal	Difficult
Elec	RhBr		1	2	7	2	0	8	2	1	7
			Certainty=34%		Medium	Certainty=20%		Low	Certainty=19%		Low
											
CaBo			1	2	7	2	0	8	2	1	7
			Certainty=34%		Medium	Certainty=20%		Low	Certainty=19%		Low
											
Elec	RiRe		5	3	2	3	3	4	3	2	5
			Certainty=22%		Medium	Certainty=17%		Low	Certainty=13%		Low
											
CaBo			5	3	2	3	3	4	3	2	5
			Certainty=22%		Medium	Certainty=17%		Low	Certainty=13%		Low
											

Stunning	Indicator	Phase							Easiness of application		
			Distributions								
			Phase 1: Stunning			Phase 2: Neck-cut			Phase 3: Bleeding		
			Answers			Answers			Answers		
			Easy	Normal	Difficult	Easy	Normal	Difficult	Easy	Normal	Difficult
Elec	ImCo		3	3	4	0	0	5	0	0	5
			Certainty=17%		Low	Certainty=100%		High	Certainty=100%		High
											
CaBo			4	3	3	0	0	5	0	0	5
			Certainty=17%		Low	Certainty=100%		High	Certainty=100%		High
											
Elec	VoCa		10	0	0	8	1	0	7	1	0
			Certainty=100%		High	Certainty=69%		High	Certainty=67%		High
											
CaBo			9	0	0	4	1	0	4	1	0
			Certainty=100%		High	Certainty=60%		High	Certainty=60%		High
											

The certainty within the judgements of 'Easiness of application' is described with 1 minus the relative standard deviation of the mean assuming the observed distribution. To support the interpretation, following classes are used:

0% ≤ certainty ≤ 20% – low/20% < certainty < 50% – medium/50% ≤ certainty ≤ 100% – high